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21

ENGINEERING FLIGHT TEST OF THE AH-1G HELICOPTER HUEYCOBRA

PHASE B

PART 2

FINAL REPORT

JOHN R. MELTON
PROJECT ENGINEER

GARY C. HALL
MAJOR, TC
US ARMY
PROJECT OFFICER/PILOT

MAY 1969

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US ARMY AVIATION SYSTEMS TEST ACTIVITY
EDWARDS AIR FORCE BASE, CALIFORNIA 93523

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ABSTRACT

Part 2 of the AH-1G helicopter Phase B test was conducted at Bell Helicopter Company, Fort Worth, Texas, from 8 September to 26 September 1967 by the US Army Aviation Systems Test Activity, Edwards AFB, California. Part 2 comprised the Phase B testing of the basic configuration (XM-157 rocket launcher outboard on each wing). Earlier tests (Phase B, Part 1) were of the Scout (XM-157 outboard, XM-18 inboard each wing) and Hog (two XM-159 rocket launchers on each wing) configurations. The prototype aircraft for this test was similar to the one previously tested. This test emphasized stability and control testing in the basic configuration. No new deficiencies were detected during this test. The new shortcomings detected during this test were a shallow maneuvering control-free (longitudinal cyclic force) gradient at high airspeeds, nonoptimum static cyclic control force gradients and breakout and friction values, difficult main rotor head inspection, difficult and time consuming gear box inspection, difficult and time consuming oil cooler inlet panel removal, and inadequate seals around cockpit hatches. The deficiencies and shortcomings which existed during Phase B, Part 1, testing still existed during this test.

FOREWORD

During the conduct of the AH-1G helicopter Phase B test at Bell Helicopter Company, Fort Worth, Texas, the helicopter and special instrumentation were maintained by Bell Helicopter Company personnel under contract to the US Army Aviation Systems Command.

TABLE OF CONTENTS

APPENDIXES

INTRODUCTION

BACKGROUND

1. The Phase B engineering flight testing of the AH-1G helicopter was planned to be accomplished using several test aircraft during different time periods. Testing of stability and control characteristics in the Scout and Hog configurations, firing of the TAT-102A chin turret and wing-mounted armament subsystems and jettison of wing stores were accomplished using AH-1G helicopter, S/N 66-15246. The results of those tests were reported under separate cover in Phase B, Part 1 (ref 1, app I). Stability and control tests in the basic configuration were accomplished using AH-1G helicopter, S/N 66-15248. The results of those tests are presented in this report. Firing tests of the XM-28 chin turret were accomplished using AH-1G helicopter, S/N 66-15283. The results of those tests are presented in parts 3, 4 and 5 of this report, under separate covers. Performance tests are being accomplished using AH-1G helicopter, S/N 66-15247. The results of those tests will be presented in part 6 of this report under a separate cover.

TEST OBJECTIVES

2. The objectives of this test were to provide flight test data:

a. To verify or modify the contractor's proposed flight envelope for future service tests, logistical tests, and operational use.

b. To define and allow early correction of helicopter deficiencies.

c. To provide a basis for evaluation of changes incorporated to correct deficiencies.

d. To estimate the degree to which the helicopter is suitable for the intended mission.

DESCRIPTION

3. The test aircraft, S/N 66-15248, was the second production prototype AH-1G tactical helicopter produced by Bell Helicopter Company designed specifically for the armed role. It is a tandem-seating, two-place, high-speed, conventional helicopter with a two-bladed, door-hinge-type main rotor and conventional anti-torque rotor. A three-axis stability and control augmentation system (SCAS) is used (in lieu of the stabilizer bar) to improve helicopter

stability and handling qualities. The test helicopter is powered by a Lycoming T53L-13 turboshaft engine rated at 1400 shaft horsepower (shp) at sea level (S.L.) standard day static conditions. The powerplant is derated to 1100 shp at 314 rpm rotor speed because of torque limits of the helicopter main transmission. The distinctive features of the helicopter are the narrow 36-inch fuselage, the stub mid-wings with four external store stations, and the integral TAT 102A chin turret. The turret can position the weapon 115 degrees left and right. Weapon elevation is variable from 15 to 25 degrees, depending on the azimuth position of the turret. Weapon depression is 50 degrees at all azimuth positions. The armament configurations are changed by varying wing stores. The pilot can fire all weapons in the stowed position. The copilot/gunner operates the flexible turret and can also fire the wing stores in an emergency by use of a pilot override feature. The flight control system is a positive mechanical type with conventional helicopter controls in the pilot's aft cockpit. The copilot/gunner's forward cockpit is provided with sidearm collective and cyclic controls. Control forces are reduced by hydraulic servo cylinders connected to the control system mechanical linkage. The hydraulic system is powered by dual transmission-driven pumps. A synchronized elevator is used to increase static longitudinal stability. An electrically operated mechanical force trim system connected to the cyclic and directional controls is used to induce artificial control feel and positive control centering. Ausformed steel armor protection is provided for the crew, engine fuel control, and engine compressor section. A complete aircraft description is included in references 2 and 3, appendix I, and aircraft dimensions and design information are presented in appendix IV.

SCOPE OF TEST

4. Part 2 of the AH-1G helicopter Phase B test was conducted at Bell Helicopter Company, Fort Worth, Texas, and consisted primarily of stability and control testing in the basic configuration. Vibration surveys were also conducted. The basic configuration consists of the TAT 102A chin turret with integral XM-134 minigun and one XM-157 seven-round rocket launcher outboard on each wing. Twenty-two flights were conducted for a total of 28.5 productive test hours during an elapsed calendar time of 17 days. Tests were conducted with gross weight (G.W.) variations of 7710 pounds to 8375 pounds. The flight restrictions in affect during these tests were obtained from the contractor, were approved by US Army Aviation Systems Materiel Command (USAAVSCOM), and are presented in appendix V.

METHODS OF TESTS

5. Standard US Army Aviation Systems Test Activity (USAASTA) engineering flight test methods were used in these tests. The methods are described briefly for each test in the Results and Discussion section of this report.

CHRONOLOGY

6. The chronology of this test program is as follows:

Test helicopter received	8 September 1967
Flight testing commenced	9 September 1967
Flight testing completed	26 September 1967
Draft report submitted	24 May 1968
Final draft report approved	6 September 1968

RESULTS AND DISCUSSION

GENERAL

7. This test is a continuation of the Phase B testing previously reported (ref 1, app I). Since there were only minor differences in the two test helicopters, only new problems or changes to previously reported problems will be discussed at length. Those problem areas previously reported which existed during the conduct of this test are listed below and in the Conclusions section of this report:

a. Lack of transparent sight gage for tail rotor 90-degree gearbox inspection port.

b. Inadequate and illogical fire control system.

c. Unguarded fuel control selector switch (AUTO/EMERG) in copilot/gunner's cockpit.

d. Inaccessible location for rotor speed select (beep) switch in copilot/gunner's cockpit.

e. Turret sight interference with copilot/gunner's legs.

f. Awkward location of azimuth stow locks and stow mount lock.

g. Inadequate cockpit ventilation system.

h. Inadequate directional control at some conditions within the flight envelope.

i. Undue pilot attention required to avoid exceeding the torque limits of the helicopter transmission.

8. The flight characteristics of the AH-1G helicopter in the basic configuration did not differ significantly from those evaluated and reported for the Hog and Scout configurations in Phase B, Part 1.

PILOT'S PREFLIGHT INSPECTION

9. The pilot's preflight inspection procedure is satisfactory. The 90-degree tail rotor gearbox inspection port was not transparent and prevented inspection of the gearbox fluid level.

COCKPIT EVALUATION

Pilot's Cockpit

10. Only minor differences existed between the cockpit of this test aircraft and the one previously tested. These differences are listed below:

a. Armored seats were installed in the test aircraft and impaired entry and exit but appeared to be satisfactory otherwise.

b. The canopy hatch hold-open and locking mechanism was improved and considered to be adequate.

c. The master caution panel was relocated so that the glare shield protected it from direct sunlight.

d. A redesigned attitude gyro was installed in the test aircraft. Although, it presented more useable information than the one previously installed, it was not satisfactory because of a lag which caused an excessive time to errect. Excessive errors were introduced during maneuvers.

e. The primary radio and armament switches were relocated to the center of the pilot's instrument panel allowing ease of operation with the left hand.

f. No improvements had been made in the inadequate and illogical fire control system.

11. The only new discrepancy noted in the cockpit was that the seals around both cockpit hatches were inadequate and allowed sand or dust to enter the cockpit.

Copilot/Gunner's Cockpit

12. Two changes were made in the copilot/gunner's cockpit on this aircraft: (1) the addition of the armored seat, which impaired entry and exit but appeared to be satisfactory otherwise; (2) the improved canopy hatch hold-open and locking mechanism which was satisfactory. The unguarded fuel control selector switch, the poor location of the rotor speed control (beep) switch, sight azimuth and stow locks, and interference of sight with the copilot's legs are problem areas which still exist on this test aircraft.

Cockpit Ventilation

13. The ventilation system of the test aircraft consisted of a flush mounted, adjustable outlet in the right side of the instrument panel and deck outlets on each side. Outside air was drawn into the cockpit by the ventilation system (induction type) on this test aircraft as opposed to being blown in by an electrically driven blower on the previous aircraft (ref 1, app I). This arrangement was less satisfactory from a cooling standpoint and caused more induction of foreign matter, such as sand and dust, into the cockpit. Average ambient temperatures for the test program were between 80 and 90 degrees Farenheit. Without the ventilation system in operation, the cockpit conditions rapidly became hot and stifling. Although the blower type system is better than the induction type neither of these is completely adequate. Based on personal experience in the Republic of Vietnam, it was concluded that pilot and copilot/gunner fatigue will be greatly increased because of the unsatisfactory helicopter ventilation system.

AIRSPEED CALIBRATION

14. Airspeed calibration flights were conducted to determine the position error of the test (boom) and ship's standard airspeed systems. A trailing bomb was used as an airspeed reference up to 114 knots calibrated airspeed (KCAS). The indicated airspeeds of the test aircraft were compared with the calibrated airspeeds from the trailing bomb. From 100 KCAS to limit airspeed, a T-28 airplane (pacer aircraft) with two calibrated airspeed systems was used as an airspeed reference. The indicated airspeeds of the test aircraft were compared with the calibrated airspeeds of the pacer aircraft. Both the boom and the ship's standard system were calibrated in the basic configuration during level flight, dive, climb, and autorotation. During the calibration of the standard system, the test airspeed boom was removed to prevent possible interference with the standard system pitot tube. The test results are presented in figures 1 and 2, appendix II.

15. Figure 1, appendix II, presents the results of the calibration tests of the standard system. In level flight and dive, the position error ranged from a maximum of +2.7 knots at 34 knots indicated airspeed (KIAS) to -4.9 knots at 188 KIAS. The position error of this aircraft agreed with that found for the previous test aircraft (ref 1, app I) within approximately 1 knot between 40 KIAS and 170 KIAS. Above 170 KIAS, the position error of this aircraft

did not continue to diverge rapidly as did the position error of the aircraft of reference 1, appendix I. Because of this difference between the measured position errors of test aircraft, additional testing will be required to define a representative position error for the AH-1G operator's manual. This should be done by statistical sampling of representative production aircraft.

STABILITY AND CONTROL

Longitudinal Collective-Fixed Stability

16. Longitudinal collective-fixed stability tests were conducted to define the flight control position requirements as a function of airspeed and to evaluate the collective-fixed static longitudinal stability of the helicopter. At each trim point, the collective-fixed static longitudinal stability was defined by maintaining the collective pitch control fixed at the trim condition and recording control position requirements at stabilized increased and decreased airspeeds from the trim airspeed. Each trim point of a series was flown at a constant thrust coefficient (C_t). The helicopter was stabilized at a trim airspeed and data were recorded to determine the control positions. Tests were conducted for three center of gravity (cg) locations: 191.8 inches (forward), 197.1 inches (aft), and 199.9 inches (aft) in the basic configuration. The results of these tests are presented in figures 3, 4, and 5, appendix II.

17. Longitudinal cyclic control position gradients indicated positive stability at all airspeeds for both forward and aft cg. Forward cyclic was required to increase airspeed at all conditions tested. The longitudinal cyclic control gradient was slightly steeper with a forward cg than with an aft cg; however, longitudinal characteristics were acceptable in specific cg locations. At airspeeds higher than maximum for level flight, longitudinal gradients decreased. The characteristics increased the pilot's workload in maintaining target alignment but are considered to be acceptable for operational use.

18. Figure 3, appendix II, shows that the trim collective position for 190 KCAS is lower than that for power limit level flight airspeed. At both airspeeds, engine output shaft horsepower was at transmission limit torque. This further illustrates the characteristic discussed in paragraph 47 of reference 1, appendix I. Stated briefly, if transmission limit torque is established in level flight, a dive to limit airspeed with constant collective pitch will result in a main transmission overtorque. A caution note should be included in the AH-1G operator's manual to explain this characteristic.

19. Figures 3 and 4, appendix II, illustrate that for a fixed collective position increasing airspeed in a dive requires that right pedal be applied in order to maintain a zero sideslip angle, possibly because of the cambered vertical fin. As airspeed increases, the cambered fin creates an increasing right aerodynamic force on the tail, in effect "adding left pedal" for the pilot. With a constant collective pitch, the pilot must counter this increase in fin thrust with right pedal. A right sideslip angle will result if this is not done. Maintaining zero sideslip is important during rocket firing runs. A rocket firing dive with this aircraft should not be made with fixed pedals. Coordinated flight with increasing right pedal in the dive should be maintained.

Static Lateral-Directional Stability

20. The static lateral-directional stability characteristics and effective dihedral were determined by stabilizing the helicopter at a trim airspeed, in balanced zero-sideslip flight, with collective pitch control fixed. Tests were conducted in the basic configuration at four trim airspeeds at an average cg of 191.1 inches (forward) and at two trim airspeeds at an average cg of 197.9 inches (aft). The test results are presented in figures 6 through 11, appendix II. The apparent static directional stability was strongly positive at all conditions tested. The pedal input opposing the sideslip was required to maintain the sideslip angle. The pedal gradients increased with airspeed. The apparent effective dihedral was strongly positive near trim and increased with airspeed. In left sideslip flight near the limit angle, the lateral cyclic gradient tended to decrease; however, this decrease was not considered to be objectionable. The aerodynamic side forces evidenced by bank angle in sideslip were strong, thus providing the pilot strong cues to aid him in maintaining trimmed flight. This characteristic is particularly significant in view of the requirement for right pedal in a constant collective dive as described in paragraph 19.

Dynamic Longitudinal Stability

21. Tests were conducted to insure that no unsafe dynamic stability characteristics existed within the contractor-approved flight envelope. These tests were conducted by disturbing the helicopter from trimmed stable flight with a 1-in/sec control pulse simulating a gust input, and recording and resulting helicopter motions. The tests were conducted for the basic configuration with both forward and aft cg's, 324 rpm, and at airspeeds from hover to limit airspeed. All quantitative tests were done with the SCAS-ON.

22. Dynamic longitudinal stability was excellent at all conditions tested. A longitudinal pulse resulted in a rapid excursion from trim in the same direction as the input and a quick return to the trim conditions when the controls were neutralized. Pitch rate was nonoscillatory. Pitch attitude, angle of attack, and load factor made one excursion in the direction of the input and returned to trim.

23. Lateral coupling was evident with longitudinal inputs. Figure 12, appendix II, shows an example of this characteristic. The helicopter rolled right with forward inputs and rolled left with aft inputs. This characteristic was acceptable.

Dynamic Lateral-Directional Stability

24. Dynamic lateral-directional stability tests were conducted to determine the lateral-directional damping and lateral dynamic stability characteristics of the helicopter Lateral-directional damping was defined by establishing trimmed zero sideslip flight at a selected airspeed. A transient sideslip angle was then introduced with simultaneous opposite lateral cyclic and pedal inputs; the controls were then returned to trim. The resulting helicopter motions were recorded. The characterisitics of sideslip oscillations were analyzed to determine the dynamic lateral-directional damping ratio and damped natural frequency.

25. Figure 13, appendix II, shows the lateral-directional damping ratio as a function of both damped natural frequency and calibrated airspeed. Figures 14 and 15 show typical time history records of lateral-directional pulses at 113 and 169 KCAS. With SCAS-ON, lateral-directional dynamic stability was excellent, contributing to the mission suitability of the aircraft. The roll and yaw SCAS eliminated any tendency toward a residual dutch roll. Reference 4, appendix I, proposed a desired value of damping ratio of 0.4 for tactical helicopters. The damping ratio defined during this evaluation ranged from greater than one to the minimum "desired" value of 0.4 at approximately 170 KCAS. With SCAS-OFF, the damping ratio was 0.1 or less for all conditions tested. This is less than one-half the proposed requirement (ref 4, app I) of approximately 0.2 to 0.27 through the range of damped natural frequency of this aircraft. This characteristic of low lateral-directional damping is not severe enough to limit the safe flight envelope of the helicopter with SCAS inoperative. However, it may seriously detract from the SCAS-OFF mission effectiveness of the aircraft.

26. Figures 16 and 17, appendix II, show time histories of left lateral pulses at 136 KCAS with similar aircraft configura-

tions. Figure 16 is with SCAS-ON and figure 17 is with SCAS-OFF. The SCAS-ON reaction to the lateral pulse was quite stable, showing only a roll disturbance from trim in the direction of the input and a rapid return to trim. A degree of adverse yaw was evident. With SCAS-OFF, as in figure 17, the left lateral pulse initiated a divergent roll with a frequency of approximately 0.25 cps. The pilot considered the oscillations to be uncomfortable. The records show large oscillations but indicate that the rate of divergence is mild. Each cycle of the roll oscillation caused engine oscillations. As reported in reference 1, appendix I, a fixed collective left roll decreases rotor speed so that the governor increases power output. With the divergent roll rate oscillations, encountered in this test, engine torque oscillations were large (approximately ± 5 psi) with a roll rate oscillation of approximately ± 25 degrees per second within 7 seconds of the input. The divergent SCAS-OFF roll oscillation can be damped by the pilot with periodic lateral cyclic inputs and is not considered to be hazardous. However, this characteristic would result in marginal instrument flight capability with SCAS inoperative.

Controllability

27. Longitudinal controllability was evaluated by analyzing the helicopter motions following an abrupt longitudinal cyclic control displacement. Figure 18, appendix II, shows a typical time history of an aft longitudinal cyclic step input. Longitudinal response characteristics are summarized in figures 19 and 20 for both a forward and an aft cg in the basic configuration.

28. For the conditions tested, longitudinal response characteristics were good. Maximum load factors following longitudinal inputs were proportional to the size of the inputs at given airspeeds. The transient load factor characteristic showed the response concave downward at 0.2 seconds following the input. Previous tests of the AH-1G helicopter (ref 1, app I) in the heavier Hog configuration showed somewhat overdamped longitudinal response. This condition was improved in the lighter basic configuration used for this evaluation, particularly at a forward cg. The load factor time constant or time to reach 0.63 maximum load factor was reduced from approximately 1.5 seconds for aft inputs in the Hog configuration to 1.05 seconds or less in the basic configuration (forward cg). The smaller time constants improved longitudinal control "feel", allowing more precise longitudinal maneuvering.

29. Lateral controllability was evaluated by analyzing the helicopter motions following a rapid lateral cyclic control input. Typical time histories of lateral step inputs are presented in

figures 21 through 24, appendix II, and lateral response characteristics are summarized in figures 25 through 27. Following a lateral step input, roll rate increased rapidly and became steady in proportion to lateral stick displacement. This "rate steering" is particularly important when weapons subsystems must be aimed by pointing the aircraft. The lateral response characteristics greatly enhanced the suitability of the AH-1G as a weapons platform.

30. Engine torque change with lateral control is the one aircraft characteristic which detracted from the otherwise excellent lateral response of the helicopter. A left lateral input resulted in a rapid increase in engine output power, which could result in a main transmission overtorque at high power settings. This characteristic is discussed further in paragraph 34.

Maneuvering Stability

31. Tests were conducted to evaluate the maneuvering stability characteristics of the helicopter in terms of cyclic control force and position gradients as a function of load factor (g). The symmetrical pull-up test method was used to evaluate these characteristics. In this test the helicopter was stabilized in 1.0g level flight at the desired trim airspeed and altitude with all control forces trimmed to zero. While collective pitch, power, and cyclic force trim were maintained fixed, a cyclic pull-up was executed to gain altitude. The helicopter was pushed into a dive and allowed to accelerate. Near trim airspeed, a symmetrical pull-up was executed so as to attain trim airspeed, trim altitude, and the desired load factor as the helicopter pitch attitude passed through trim. The results of these tests are presented in figures 28 and 29, appendix II.

32. For the limited conditions tested, the helicopter possessed both positive control-fixed and control-free maneuvering stability. An increasing aft (pull) control force and an increasing aft stick displacement were required for an increased load factor. Because the system is boosted, the longitudinal force gradient is due only to the springs of the artificial force-feel trim system.

A positive control-fixed (longitudinal cyclic position) gradient yields a positive control-free (longitudinal cyclic force) gradient. It is noteworthy that in this configuration the control-free gradient is less at higher airspeeds, indicating that very little force is required to obtain higher g levels during the high speed maneuvers. This condition is not desirable and should be corrected.

POWER MANAGEMENT

33. A particularly significant characteristic of the helicopter was that a lower collective pitch setting was required to maintain maximum rated power in a limit airspeed dive than at power limit level flight airspeed. This characteristic was discussed in paragraph 18 and illustrated in figure 3, appendix II. When a dive was made from maximum cruise airspeed, collective had to be lowered or a transmission overtorque would occur. To avoid transmission overtorque under these conditions, either excessive pilot attention or an engine limiter is required during this maneuver. Due to the mission of this aircraft, the amount of pilot attention required to avoid transmission overtorque is considered highly undesirable.

34. During flight conditions requiring 1100 shp, such as full power climb or level flight at power limit airspeed, the left lateral controllability was limited by the main transmission torque limits. An abrupt left lateral cyclic input caused the rotor speed to decrease at a constant collective pitch setting. The engine N_2 governor would sense the rotor speed decrease and increase the fuel flow and thus the engine power. In order to avoid transmission overtorque in service use, either excessive pilot attention is required or the aircraft must be equipped with a torque limiting device. This deficiency should be corrected prior to deployment of the helicopter for operational use.

SIMULATED ENGINE FAILURE CHARACTERISTICS

35. Simulated engine failures were conducted to determine the reaction of the helicopter to sudden power loss or engine failure and to evaluate the recovery techniques recommended by the contractor. These tests were conducted by stabilizing the helicopter at the desired trim condition and then simulating a sudden power loss by rapidly rotating the twist grip to the flight-idle position. The control trim position was maintained until corrective action was considered necessary. These tests were conducted in the basic configuration with an average gross weight of approximately 8283 pounds at airspeeds up to 177 KCAS. Time histories of typical throttle chops are presented in figures 30 through 32, appendix II.

36. The reaction of the AH-1G helicopter to a power failure at high-speed, high-power conditions was rapid and pronounced, requiring immediate positive corrective action by the pilot. Follow-

ing a power failure at speeds greater than 130 KCAS, the helicopter rolls and yaws. The angular rates generated drove all three SCAS actuators hard-over. Rotor speed decay rate is high at the high collective pitch settings required at these airspeeds. Minimum transient rotor speeds observed during these tests were generally between 260 and 280 rpm. In order to maintain flight rotor speed and to slow the helicopter to normal autorotation airspeeds, a firm cyclic flare must be initiated and held until the helicopter has slowed to approximately 120 KCAS. The cyclic flare must be maintained as the collective is decreased so that the rotor remains loaded during the maneuver. Without the positive load on the rotor while lowering the collective, very small cyclic movements result in very high rotor flapping angles. Maintaining the firm cyclic flare a sufficient time for the airspeed to decrease to approximately 120 KCAS resulted in rather large nose up pitch attitudes. Figure 32, appendix II, shows that from an entry speed of 177 KCAS, a cyclic flare of 1.0 to 1.6g was maintained for a period of 9 seconds with a pitch attitude change of 22 degrees (10 degrees down to 12 degrees nose up attitude).

37. The engine failure recognition and reaction times required of the pilot are very short. Maximum delay times for initiation of cyclic flare are on the order of 0.5 to 1.0 second; however, this is a difficult parameter to define. The maximum collective delay is a variable depending upon the degree of cyclic flare used. Figure 31, appendix II, shows a collective delay of 2.2 seconds with a firm cyclic flare. It was noted that in the basic configuration much earlier reduction of collective pitch was required to maintain rotor speed than was experienced in the Hog and Scout configurations. With this exception the throttle chop characteristics of the AH-1G were very similar in all configurations tested. Two considerations favorably influence accepting these short cyclic flare time delays. First the pilot is afforded very ample warnings (audible, visual, and kinesthetic) that an engine failure has occurred. Second, at the conditions where the power failure characteristics are most objectionable (high speed and high power), a cyclic flare and decrease in airspeed are rather natural, instinctive reaction.

38. It is considered that with proper pilot training the airspeed envelope of the helicopter need not be restricted. However, for the power failure characteristics of the AH-1G to be acceptable, proper pilot technique for engine failure recovery at high speed must be demonstrated and emphasized during transition training. Appropriate warning must be included in the operator's manual along with a discussion of recovery techniques.

SCAS-OFF EVALUATION

39. Throughout the conduct of this test the SCAS was periodically turned off. Although the SCAS-OFF handling qualities deteriorated drastically, the helicopter could be flown throughout its flight envelope. No limitation of the flight envelope with the SCAS inoperative is recommended. Mission continuation/abort decisions in the event of SCAS failure must be based on the situation; however, with SCAS inoperative, the AH-1G stability and controllability characteristics are markedly degraded. Suitability as a weapons platform is greatly reduced.

40. The roll oscillation described in paragraph 26 became very objectionable without SCAS damping. The accuracy of attitude aimed wing stores is questionable primarily because of this characteristic. Roll response deteriorated without SCAS; thus, precise heading changes were difficult to make rapidly, with a tendency toward overcontrolling. Longitudinal maneuvering characteristics also deteriorated, so that accurate control of load factor demanded excessive pilot attention. The degree to which the SCAS-OFF handling qualities of the helicopter are objectionable is dependent upon air turbulence. In moderate turbulence the effectiveness of the helicopter SCAS-OFF as a weapons platform may be severely limited.

CYCLIC CONTROL SYSTEM FORCES

41. The cyclic control system forces as a function of control displacement were measured with the helicopter on the ground using a hand-held force gage, with the rotor stationary, and with hydraulic pressure supplied by a ground power unit. The results are shown in figures 33 through 36, appendix II. In general, breakout and friction forces were higher than those normally considered to be desirable and are marginally acceptable. It is believed that these high breakout and friction forces (5 to 7 pounds) were incorporated to mask the basic problem of SCAS-pylon aerodynamic load coupling as discussed in detail in reference 1, appendix I. These high breakout and friction forces make it more difficult for the pilot to make small precise aircraft attitude changes and detract from the ability of the aircraft to perform its mission, since the fixed weapons are aimed with the aircraft.

42. The lateral cyclic static imbalance noted in reference 1 and 5, appendix I, appeared to be corrected when forces were measured on the ground at the neutral longitudinal cyclic position. However in coordinated flight at other longitudinal cyclic positions the imbalance was still present to a much lesser degree. In order to

maintain coordinated flight, a small constant right lateral force was required at some forward flight speeds. This lateral force could not easily be trimmed out and was mildly disconcerting to the pilot. The static imbalance was more noticeable when flying from the front seat. The location of the sidearm cyclic was such that the steady right force had to be exerted by the extended forearm. This force proved to be slightly fatiguing to the copilot after a short period of time. Static lateral control force balance at all airspeeds will improve the operational suitability of the helicopter.

VIBRATION SURVEY

43. Tests were conducted to determine the vibration characteristics of the test helicopter and to check compliance with deviation 1, page 95, reference 2, appendix I. These data were also collected during Phase B, Part 1. Prior to beginning of Phase B, Part 1 testing, adequate calibration of the vibration instrumentation was not possible on available calibration equipment. Rather than delay this test, the uncalibrated vibration instrumentation was installed on the test aircraft. The same instrumentation was used for Phase B, Part 2 tests and was calibrated after Phase B, Part 2, testing was completed. The results of these vibration surveys are included in this report. The test results are presented in figures 37 through 60, appendix II. The vibration levels for all conditions tested complied with the requirements of deviation 1, page 95, reference 2, appendix I.

MISCELLANEOUS

44. The following miscellaneous items were noted during this test program:

a. Inspection of the main rotor head is difficult because of the lack of handholds or steps for access to this area.

b. Inspection of the 90-degree tail rotor gearbox is difficult and time consuming because of the large number of screws that must be removed to permit access. These screws should be replaced by quick-release fasteners. This item is part of the daily maintenance inspection.

c. Removal of the oil cooler inlet panel is difficult and time consuming because of the large number of screws securing it. These screws should be replaced by quick release fasteners. This item is part of the daily maintenance inspection.

d. Although specific tests were not conducted during normal hovering operations it was noted that there are areas of inadequate in ground effect (IGE) directional control which severely limited the IGE flight envelope.

CONCLUSIONS

GENERAL

45. The following general conclusions were reached as a result of Part 2 of the AH-1G Phase B test:

a. The flight characteristics of the AH-1G after power failure require immediate corrective action by the pilot. Only a short recognition and reaction time delay is available for these corrective actions (para 37).

b. Without the SCAS, flight throughout the flight envelope is possible, but the effectiveness of the helicopter as a weapons platform may be severely limited (para 26 and 39).

c. The airspeed position error for production AH-1G helicopters is not adequately defined. The calibrations conducted by the contractor and the Army do not agree on the first AH-1G helicopters produced (para 14 and 15).

DEFICIENCIES AND SHORTCOMINGS AFFECTING MISSION ACCOMPLISHMENT

46. Correction of the following deficiencies is mandatory for acceptance of the aircraft:

a. Excessive pilot attention was required to avoid exceeding the torque limits of the helicopter transmission in dives and rolls (para 30 and 33).

b. Directional control power was inadequate at some conditions within the flight envelope of the helicopter (para 44d).

47. Correction of the following shortcomings is desirable for improved operation and mission capabilities:

a. The seals around the pilot's and copilot/gunner's cockpit hatches are inadequate, allowing sand and dust to enter the cockpit (para 11).

b. The maneuvering longitudinal control free (longitudinal cyclic force) gradients are shallow at high airspeeds (para 32).

c. The high cyclic control forces and lateral inbalance have not been corrected for all flight conditions (para 41 and 42).

d. Inspection of the main rotor head is difficult because of the lack of handholds and steps for access to this area (para 44a).

e. Inspection of the 90-degree tail rotor gearbox is difficult and time consuming (para 44b).

f. Oil cooler inlet panel removal is difficult and time consuming (para 44c).

g. The following items were previously reported in Phase B, Part 1 and have not been corrected:

(1) The sight gage in the gearbox is not transparent (para 9).

(2) The attitude gyro has an unacceptable lag time (para 10d).

(3) The fuel control emergency switch in the copilot/gunner's cockpit is unguarded (para 12).

(4) The fire control system is inadequate and illogical (para 10f).

(5) The copilot/gunner's flexible sight interferes with copilot/gunner's right leg (para 12).

(6) The rotor speed control (beep) switch in the copilot/gunner's cockpit cannot be reached while changing collective pitch (para 12).

(7) Poor location of azimuth and mounting stow locks (para 12).

(8) Inadequate cockpit ventilation system (para 13).

RECOMMENDATIONS

48. It is recommended that the following be accomplished to improve the AH-1G helicopter for operational use:

a. The deficiencies, correction of which is mandatory, be corrected prior to operational use of the AH-1G helicopter.

b. The shortcomings, correction of which is desirable, be corrected on a high-priority basis.

c. Immediate action be taken to correct deficiencies and shortcomings previously reported which still exist.

d. Power failure characteristics be emphasized and demonstrated during pilot transition training. Appropriate warning and explanation of recovery technique be entered in the operator's manual.

e. The flight envelope of the helicopter not be restricted following an SCAS failure.

f. Additional testing be conducted to determine the adequacy of IGE directional control.

g. Automatic torque limiting be provided in order to avoid exceeding the torque limit of the main transmission.

h. The cockpit ventilation system be improved.

APPENDIX I. REFERENCES

1. Final Report, USAAVNTA Project No. 66-06, "Engineering Flight Test of the AH-1G Helicopter (Hueycobra), Phase B, Part 1," January 1968.

2. Report No. 209-947-016, "Detail Specification for Model AH-1G Helicopter," Bell Helicopter Company, 11 July 1966.

3. TM-55-1520-221-10, "Operator's Manual, Army Model, AH-1G Helicopter," Headquarters, Department of the Army, April 1967.

4. Proposed Military Specification MIL-H-8501B, "Helicopter Flying and Ground Handling Qualities, General Requirements For," 3 June 1967.

5. Military Specification MIL-H-8501A and Amendment 1, "Helicopter Flying and Ground Handling Qualities, General Requirements For," 3 April 1962.

6. USAAML Technical Report 65-45, RTM 37, "Suggested Requirements for V/STOL Flying Qualities," US Army Aviation Materiel Laboratories, June 1965, AD 617748.

7. Final Report, USAAVNTA Project No. 65-30, "Engineering Flight Evaluation of the Bell Model 209 Armed Helicopter," May 1966.

8. Letter, STEAP-DS-TI, Aberdeen Proving Ground, Subject: "Test Directive, Engineering/Logistical Evaluation Test of AH-1G Helicopter (Hueycobra)," 13 Sep 1966.

9. Test Plan, USAAVNTA Project No. 66-06, "Engineering Flight Test of the AH-1G Helicopter (Hueycobra)," April 1967.

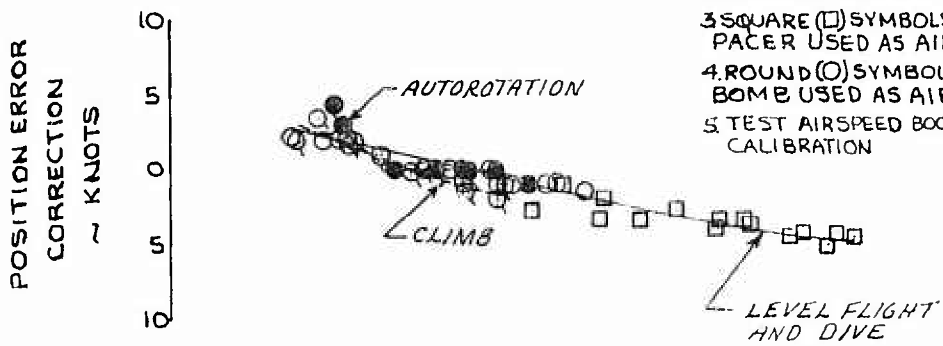
APPENDIX II. TEST DATA

FIGURE No. 1
AIRSPEED CALIBRATION
AH-1G USA S/N 615248

GROSS WEIGHT ~ LBS	C.G. STATION ~ IN.	DENSITY ALTITUDE ~ FT.	ROTOR SPEED ~ RPM	CONFIGURATION
8170	194.2	4920	324	BASIC

STANDARD SYSTEM

NOTES: 1. FLAGGED SYMBOLS DENOTE CLIMB
2. SHADED SYMBOLS DENOTE AUTOROTATION
3. SQUARE (□) SYMBOLS DENOTE CALIBRATED PACER USED AS AIRSPEED REFERENCE.
4. ROUND (O) SYMBOLS DENOTE TRAILING BOMB USED AS AIRSPEED REFERENCE.
5. TEST AIRSPEED BOOM NOT INSTALLED DURING CALIBRATION



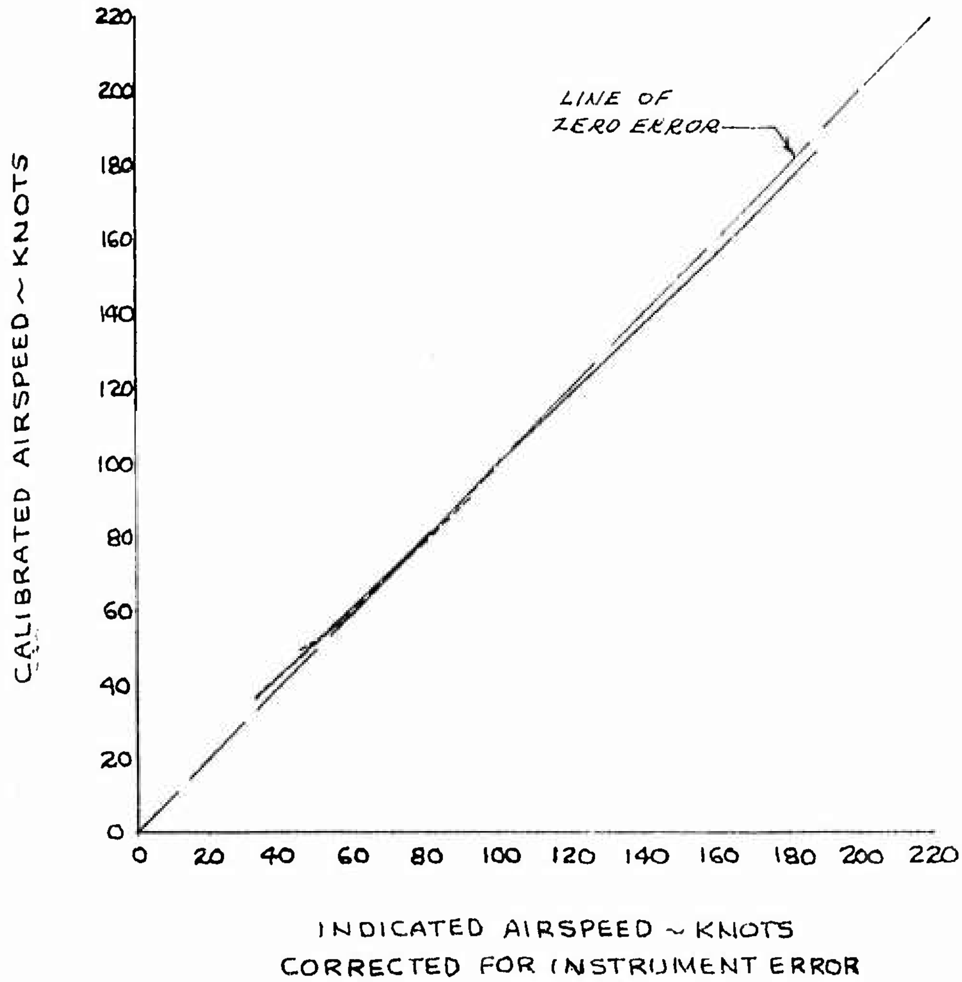


FIGURE NO. 2
AIRSPEED CALIBRATION
AH-1G USA S/N 615248

GROSS WEIGHT ~ LBS	C.G STATION ~ IN.	DENSITY ALTITUDE ~ FT.	ROTOR SPEED ~ RPM	CONFIGURATION
8170	193.4	4960	324	BASIC

BOOM SYSTEM

NOTES: 1. FLAGGED SYMBOLS DENOTE CLIMB
2. SHADED SYMBOLS DENOTE AUTOROTATION
3. SQUARE (□) SYMBOLS DENOTE CALIBRATED PACER USED AS AIRSPEED REFERENCE.
4. ROUND (O) SYMBOLS DENOTE TRAILING BOMB USED AS AIRSPEED REFERENCE

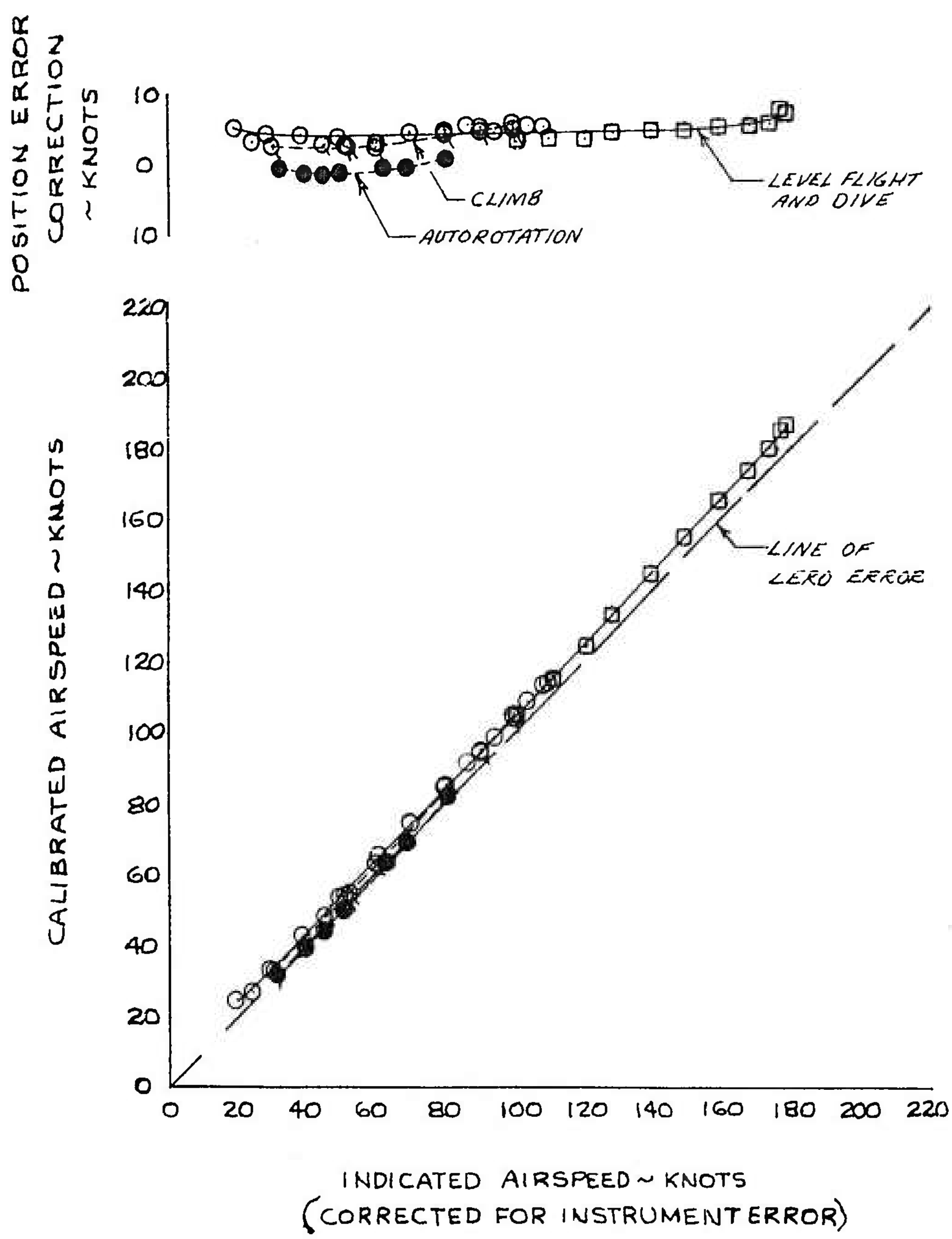


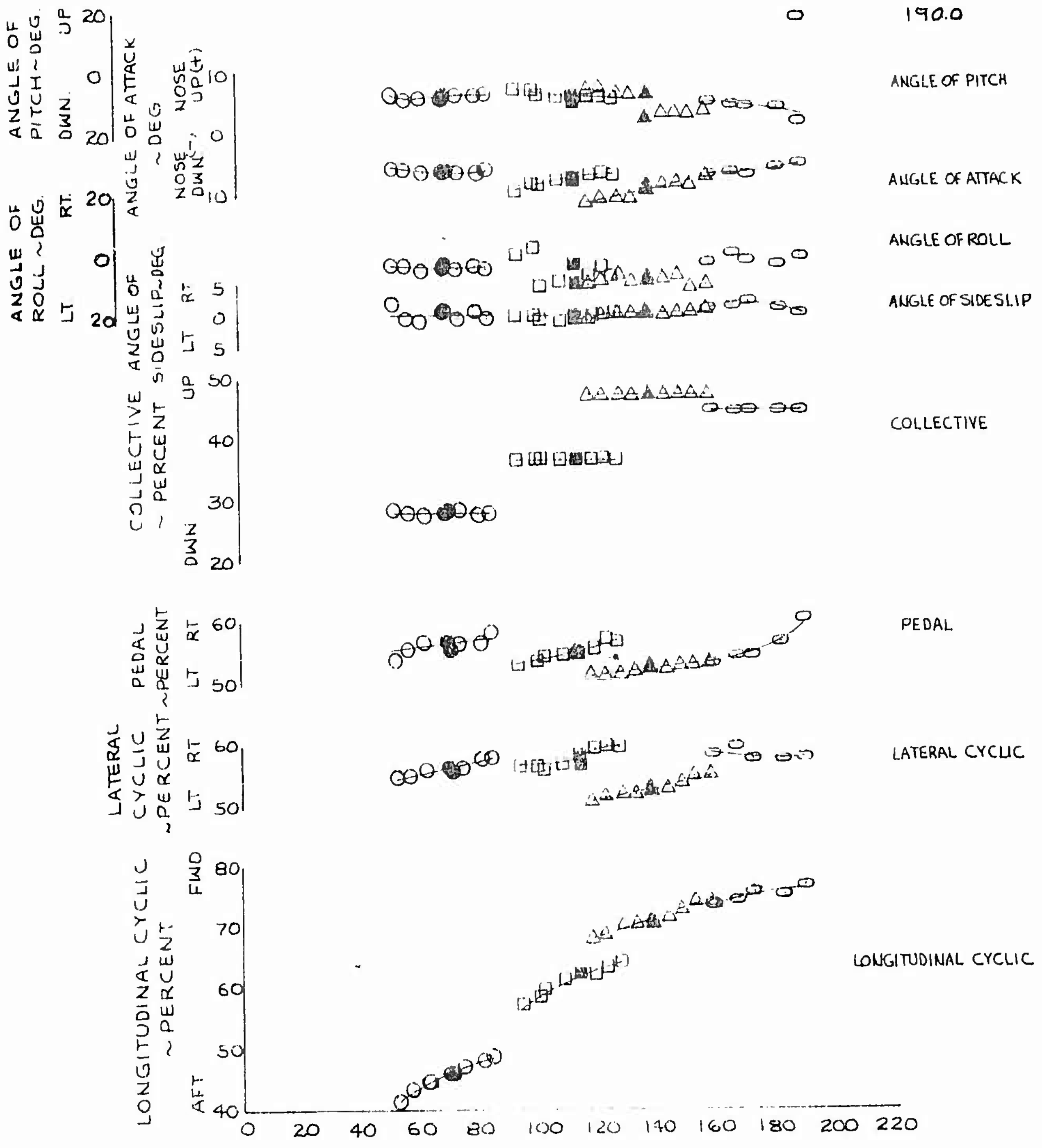
FIGURE II-5
STATIC LONGITUDINAL STABILITY
AH-1G USA S/N 615248

GROSS WEIGHT ~LBS.	C.G. STATION ~IN	DENSITY ALT ~FT	ROTOR SPEED ~RPM	CONFIGURATION
8265	191.8	9430	324	BASIC

NOTES:

1. SHADED SYMBOL DENOTES TRIM POINTS.
2. ROLL ATTITUDE INSTRUMENTATION ERRATIC.

SYMBOL	CALIBRATED TRIM AIRSPEED~KTS.
○	71.0
□	113.5
△	138.5
⬭	190.0



CALIBRATED AIRSPEED ~ KNOTS

FIGURE No. 4

STATIC LONGITUDINAL STABILITY

AH-1G USA S/N 615248

GROSS WEIGHT ~LBS.	C.G. STATION ~IN.	DENSITY ALT. ~FT.	ROTOR SPEED ~RPM	CONFIGURATION
8385	197.1	4540	324	BASIC

NOTES: 1. SHADED SYMBOL DENOTES TRIM POINTS.
2. ROLL ATTITUDE INSTRUMENTATION ERRATIC.

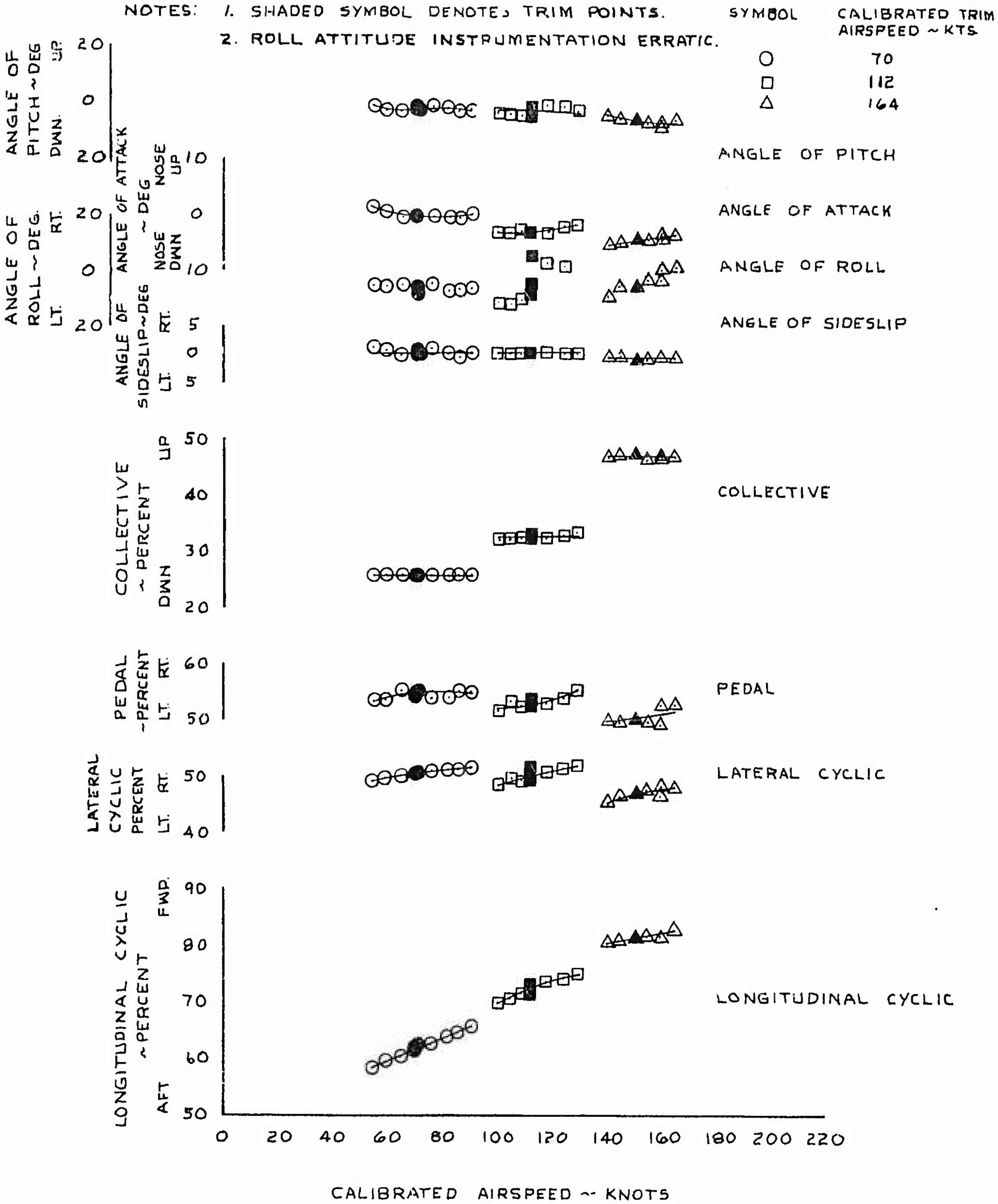


FIGURE No. 5

STATIC LONGITUDINAL STABILITY

AH-1G USA S/N 615 248

GROSS WEIGHT ~LBS	C.G. STATION ~IN	DENSITY ALT ~FT	ROTOR SPEED ~RPM	CONFIGURATION
8230	199.9	5620	324	BASIC

NOTES:

1. SHADED SYMBOL DENOTES TRIM-POINT.
2. ROLL ATTITUDE INSTRUMENTATION ERRATIC.

SYMBOL	CALIBRATED TRIM AIRSPEED~KTS
○	70.0
□	112.0
△	138.0

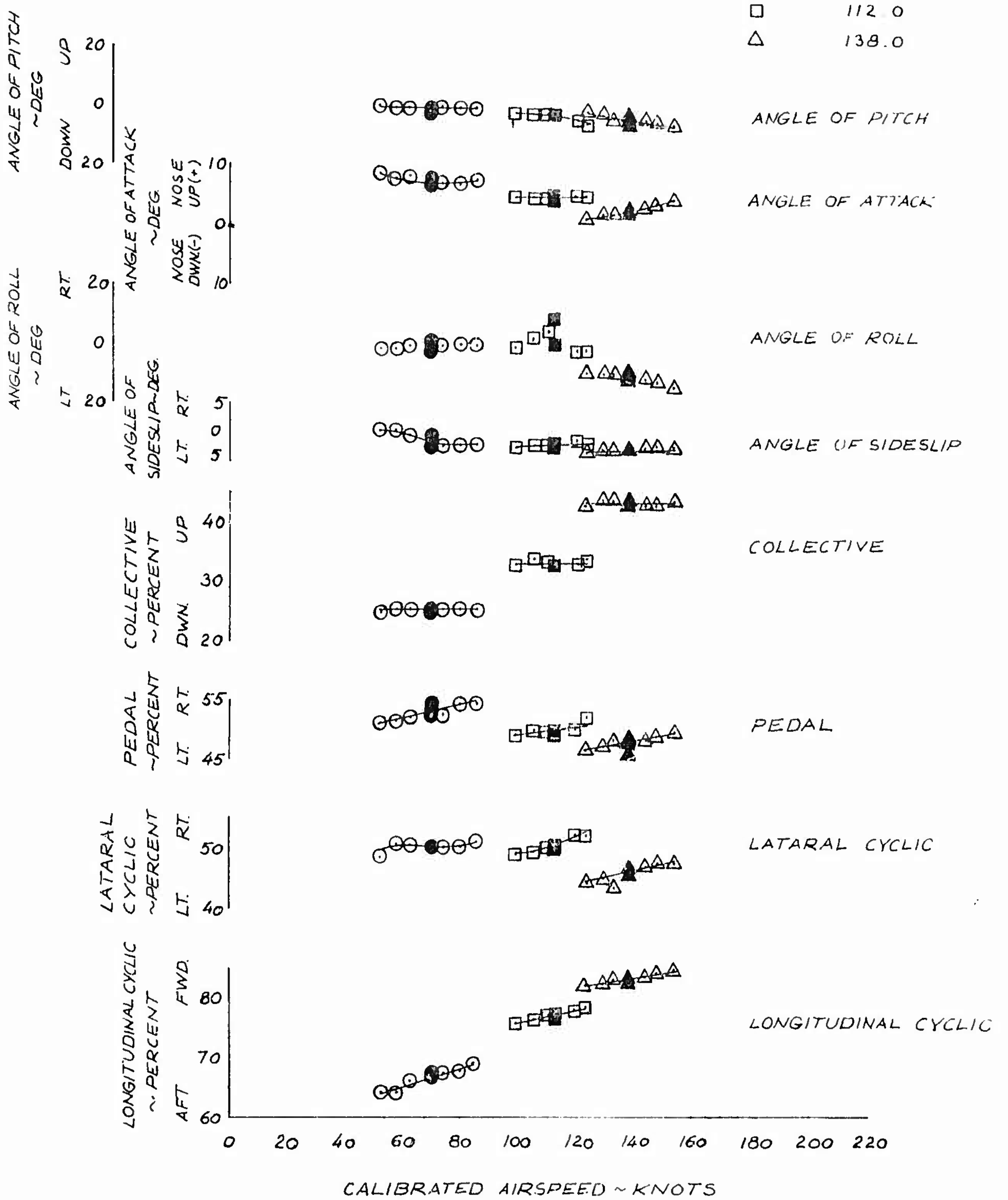


FIGURE No. 6

STATIC LATERAL DIRECTIONAL STABILITY

AH-1G USA S/N 615248

74 KNOTS CALIBRATED AIRSPEED

GROSS WEIGHT ~LBS	CG STATION ~IN.	DENSITY ALTITUDE ~FT	ROTOR SPEED ~RPM	CONFIGURATION
7780	190.7	5235	324	BASIC

NOTES:

1. SHADED SYMBOL DENOTES TRIM POINTS.
2. ROLL ATTITUDE INSTRUMENTATION ERRATIC.

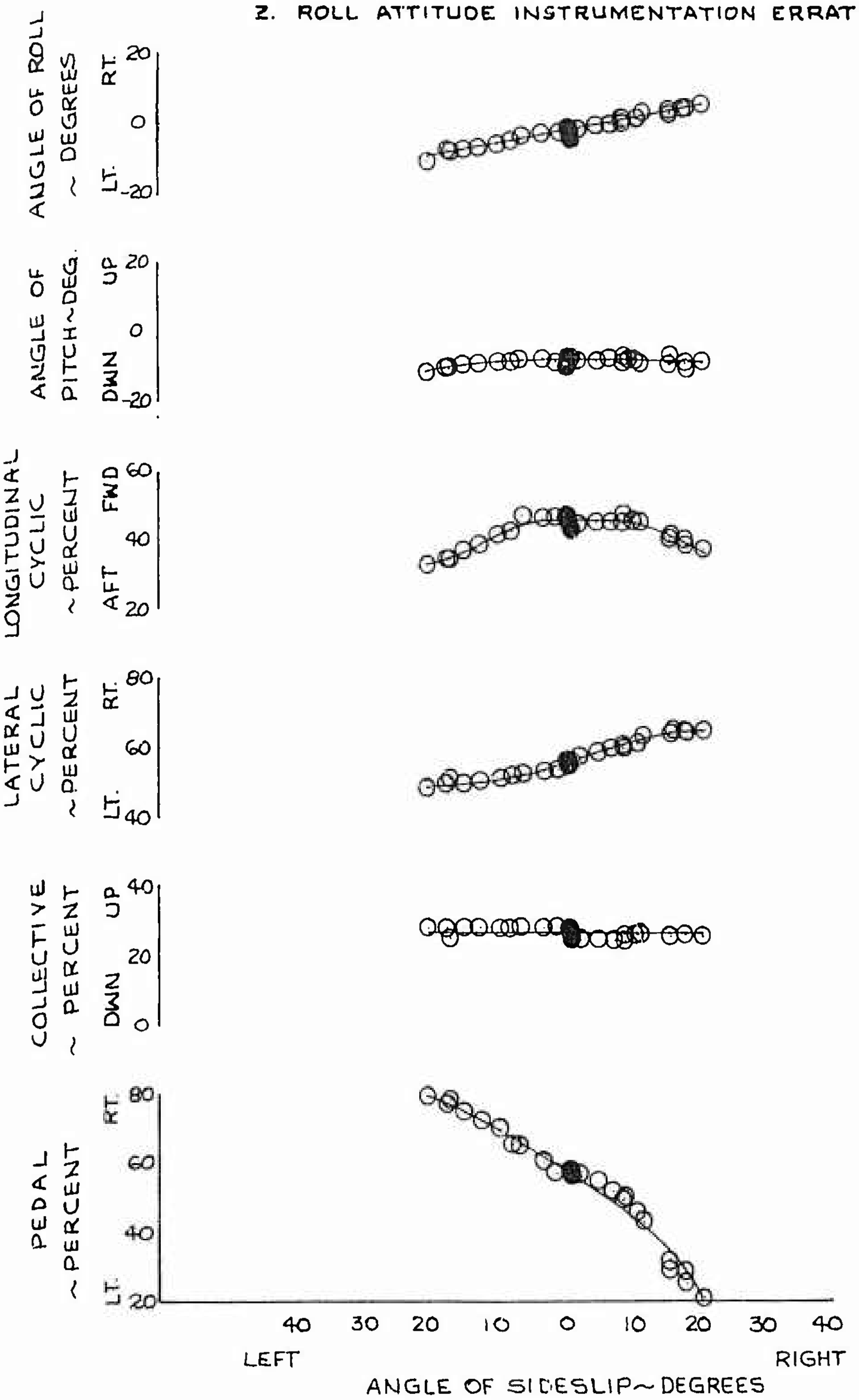


FIGURE No. 7

STATIC LATERAL DIRECTIONAL STABILITY

AH-1G USA S/N 615248

113.5 KNOTS CALIBRATED AIRSPEED

GROSS WEIGHT ~ LBS	C.G. STATION ~ IN.	DENSITY ALTITUDE ~ FT.	ROTOR SPEED ~ RPM	CONFIGURATION
8115	191.3	4450	324	BASIC

NOTES:

1. SHADED SYMBOL DENOTES TRIM POINTS.
2. ROLL ATTITUDE INSTRUMENTATION ERRATIC.

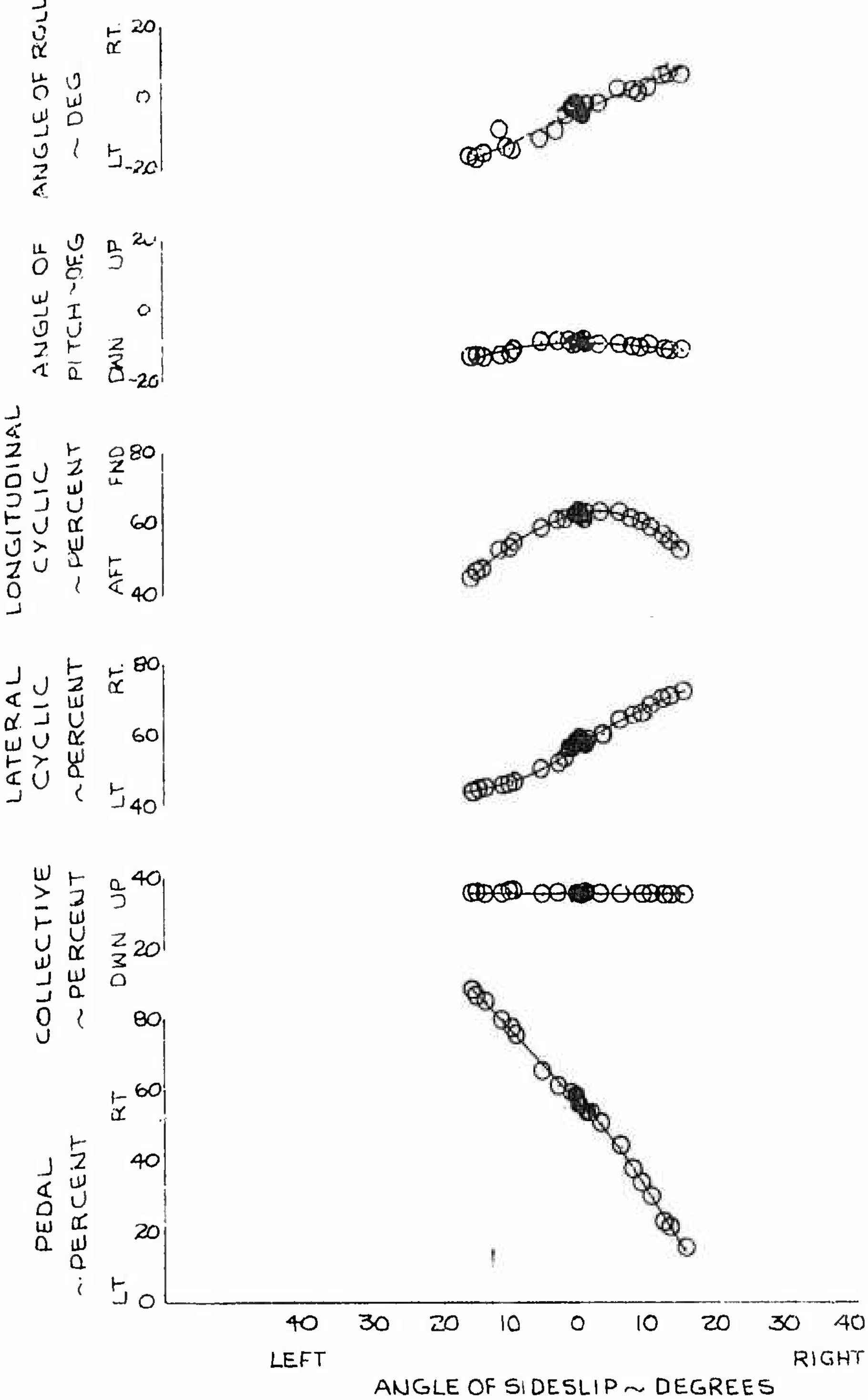


FIGURE NO. 8

STATIC LATERAL DIRECTIONAL STABILITY

AH-1G USA S/N 615248

141 KNOTS CALIBRATED AIRSPEED

GROSS WEIGHT ~ LBS	CG STATION ~ IN	DENSITY ALTITUDE ~ FT.	ROTOR SPEED ~ RPM	CONFIGURATION
8340	191.6	4920	324	BASIC

NOTES:

1. SHADED SYMBOL DENOTES TRIM POINTS.
2. ROLL ATTITUDE INSTRUMENTATION ERRATIC.

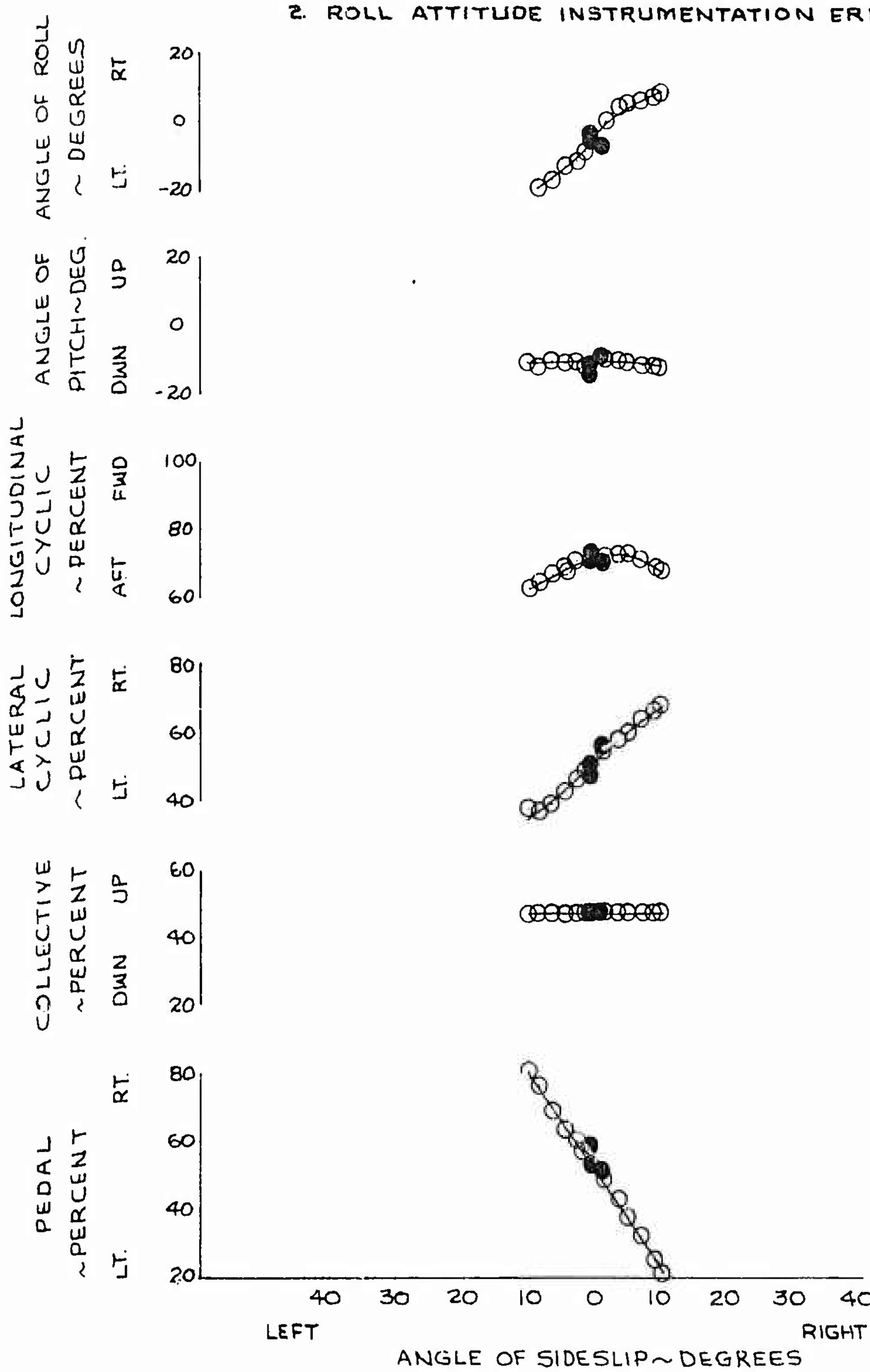


FIGURE No 9

STATIC LATERAL DIRECTIONAL STABILITY

AH-1G USA S/N 615248

187 KNOTS CALIBRATED AIRSPEED

GROSS WEIGHT ~LBS.	CG STATION ~IN.	DENSITY ALTITUDE ~FT	ROTOR SPEED ~RPM	CONFIGURATION
8110	191.3	3600	324	BASIC

NOTES:

1. SHADED SYMBOL DENOTES TRIM POINTS.
2. ROLL ATTITUDE INSTRUMENTATION ERRATIC.

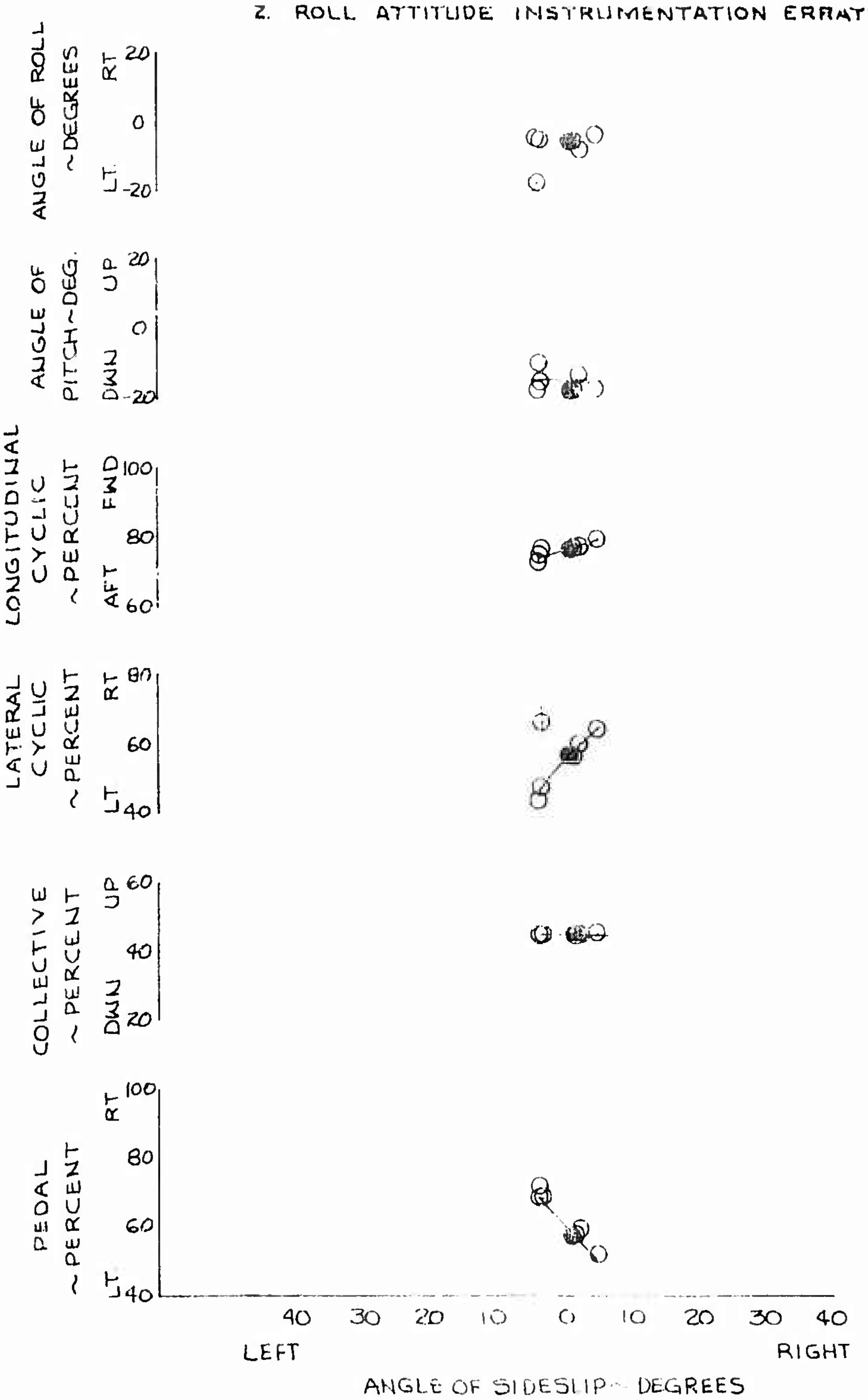


FIGURE No. 10

STATIC LATERAL DIRECTIONAL STABILITY

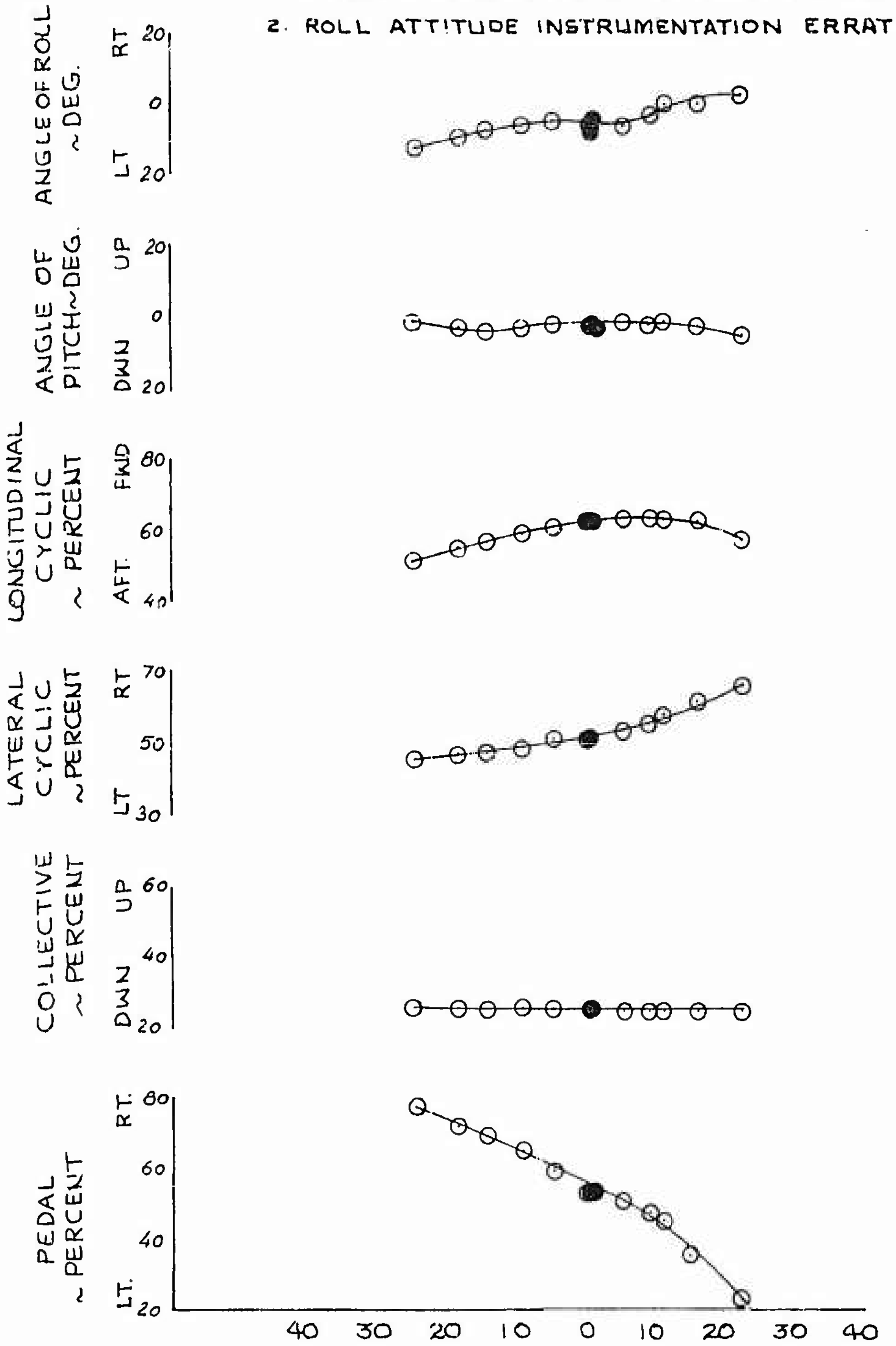
AH-1G USA S/N 615248

72.5 KNOTS CALIBRATED AIRSPEED

GROSS WEIGHT ~ LBS	C.G. STATION ~ IN.	DENSITY ALTITUDE ~ FT.	ROTOR SPEED ~ RPM	CONFIGURATION
8030	197.8	4130	324	BASIC

NOTES:

1. SHADED SYMBOL DENOTES TRIM POINTS.
2. ROLL ATTITUDE INSTRUMENTATION ERRATIC.



ANGLE OF SIDESLIP ~ DEGREES

FIGURE No. 11

STATIC LATERAL DIRECTIONAL STABILITY

AH-1G USA S/N 615248

113.5 KNOTS CALIBRATED AIRSPEED

GROSS WEIGHT ~LBS	C.G. STATION ~IN.	DENSITY ALTITUDE ~FT.	ROTOR SPEED ~RPM	CONFIGURATION
8330	198	4308	324	BASIC

NOTES:

1. SHADED SYMBOL DENOTES TRIM POINTS.
2. ROLL ATTITUDE INSTRUMENTATION ERRATIC.

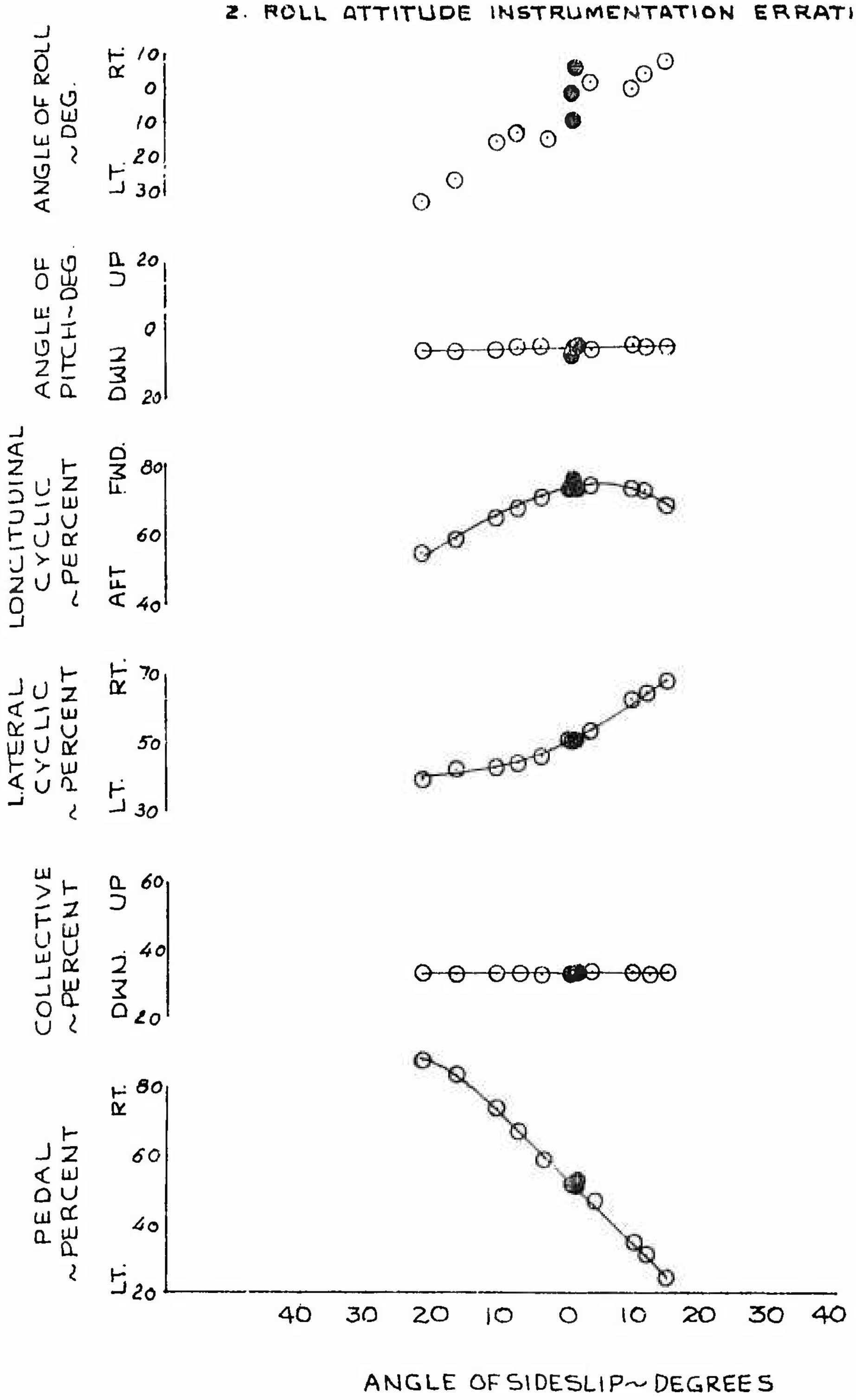
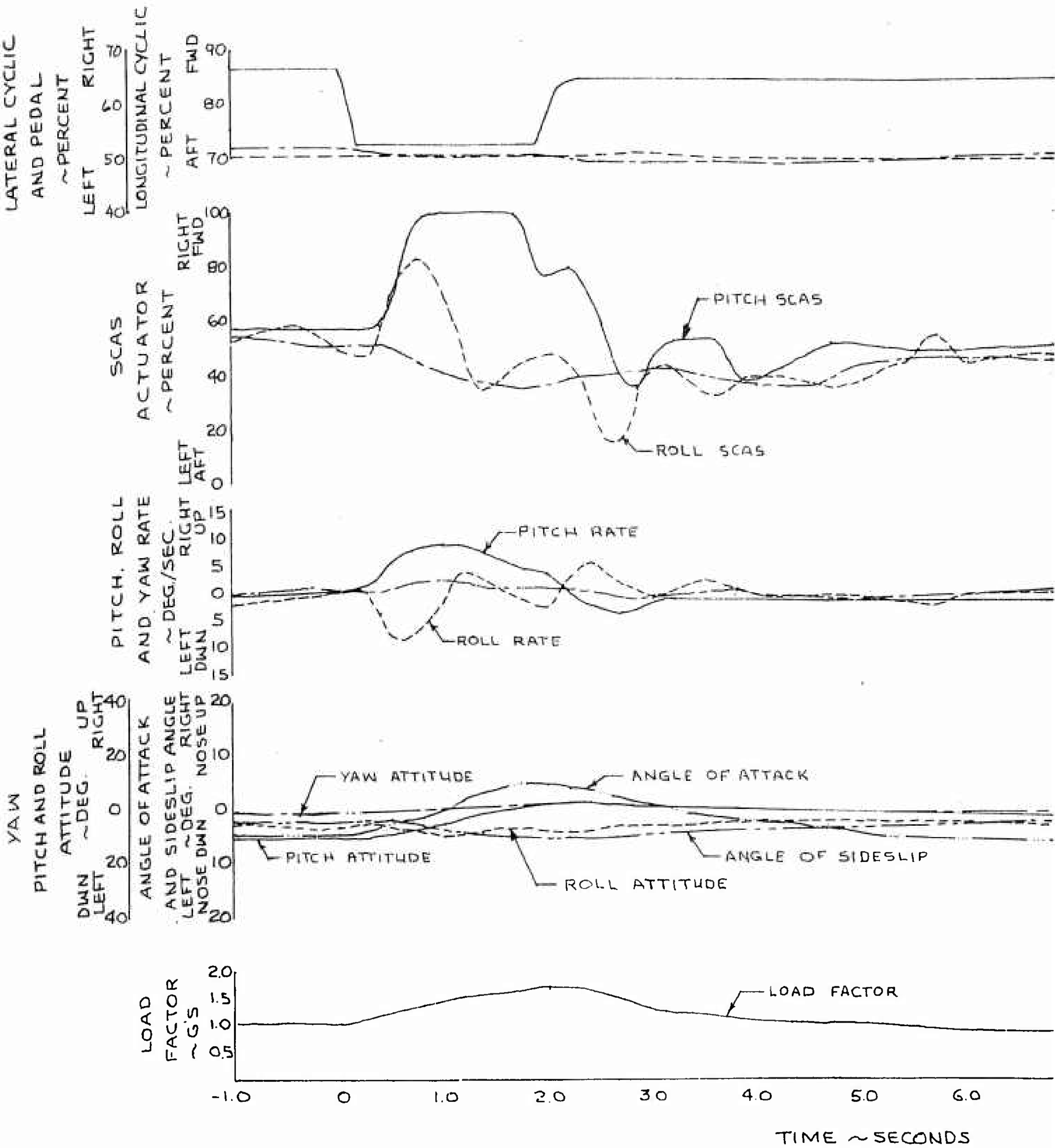


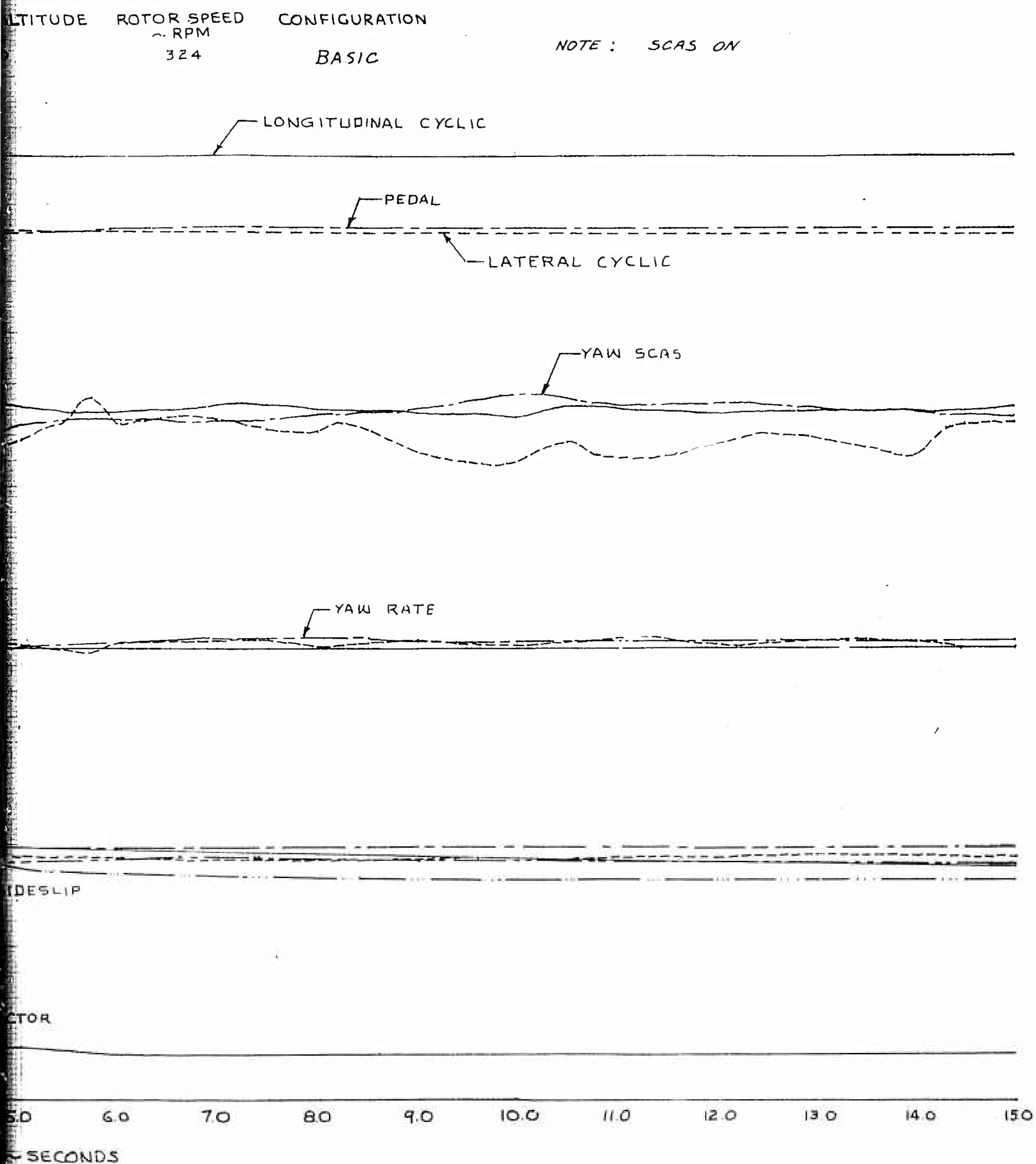
FIGURE No 12

AFT LONGITUDINAL PULSE

AH-1G USA S/N 615248

AIRSPEED ~KCAS	GROSS WEIGHT ~ LBS.	C.G STATION ~IN.	DENSITY ALTITUDE ~FT.	ROTOR SPEED ~ RPM
170	7710	199.6	4740	324




LTITUDE
ROTOR SPEED ~ RPM
324
CONFIGURATION
BASIC
NOTE : SCAS ON
LONGITUDINAL CYCLIC
PEDAL
LATERAL CYCLIC
YAW SCAS
YAW RATE
IDESLIP
CTOR
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
13.0
14.0
15.0
~ SECONDS

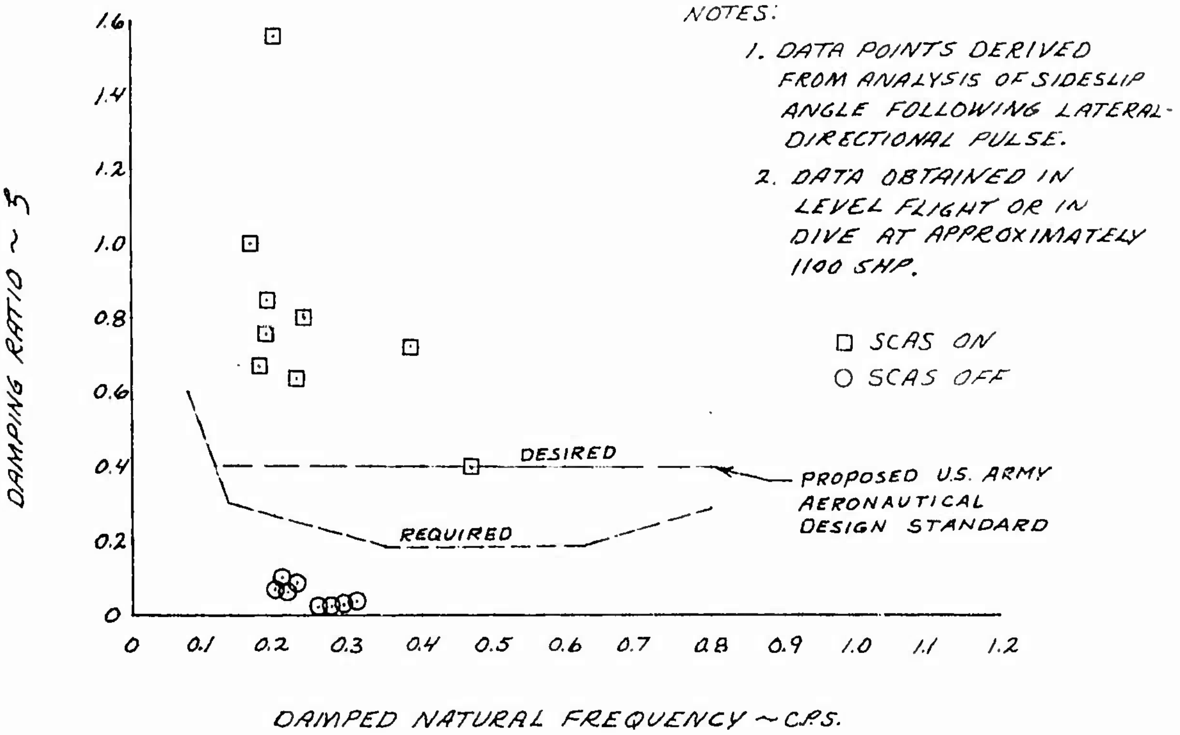
2

FIGURE NO. 13

SUMMARY LATERAL-DIRECTIONAL DYNAMIC STABILITY

AH-1G USA S/N 615248

AVG. GROSS WEIGHT	AVG. C.G. STATION	AVG. DENSITY ALTITUDE	ROTOR SPEED	CONFIGURATION
8020 LBS.	198.4 IN.	4800 FT.	324 RPM	BASIC



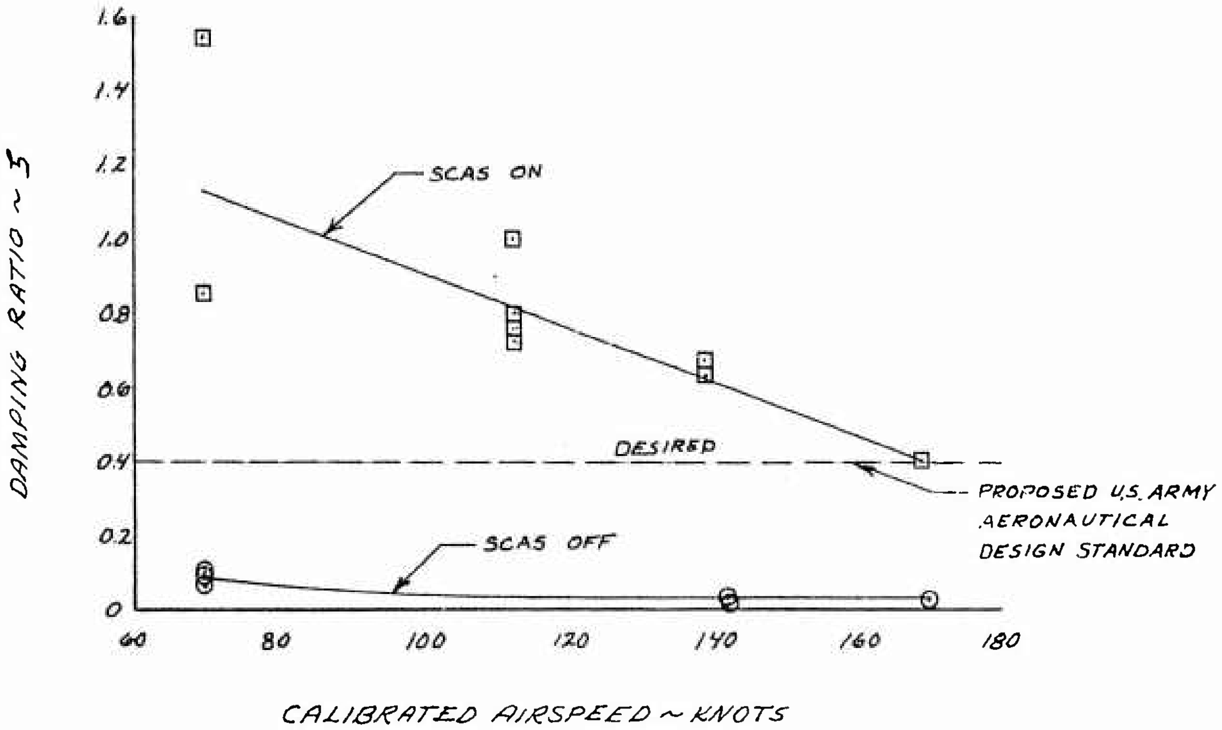
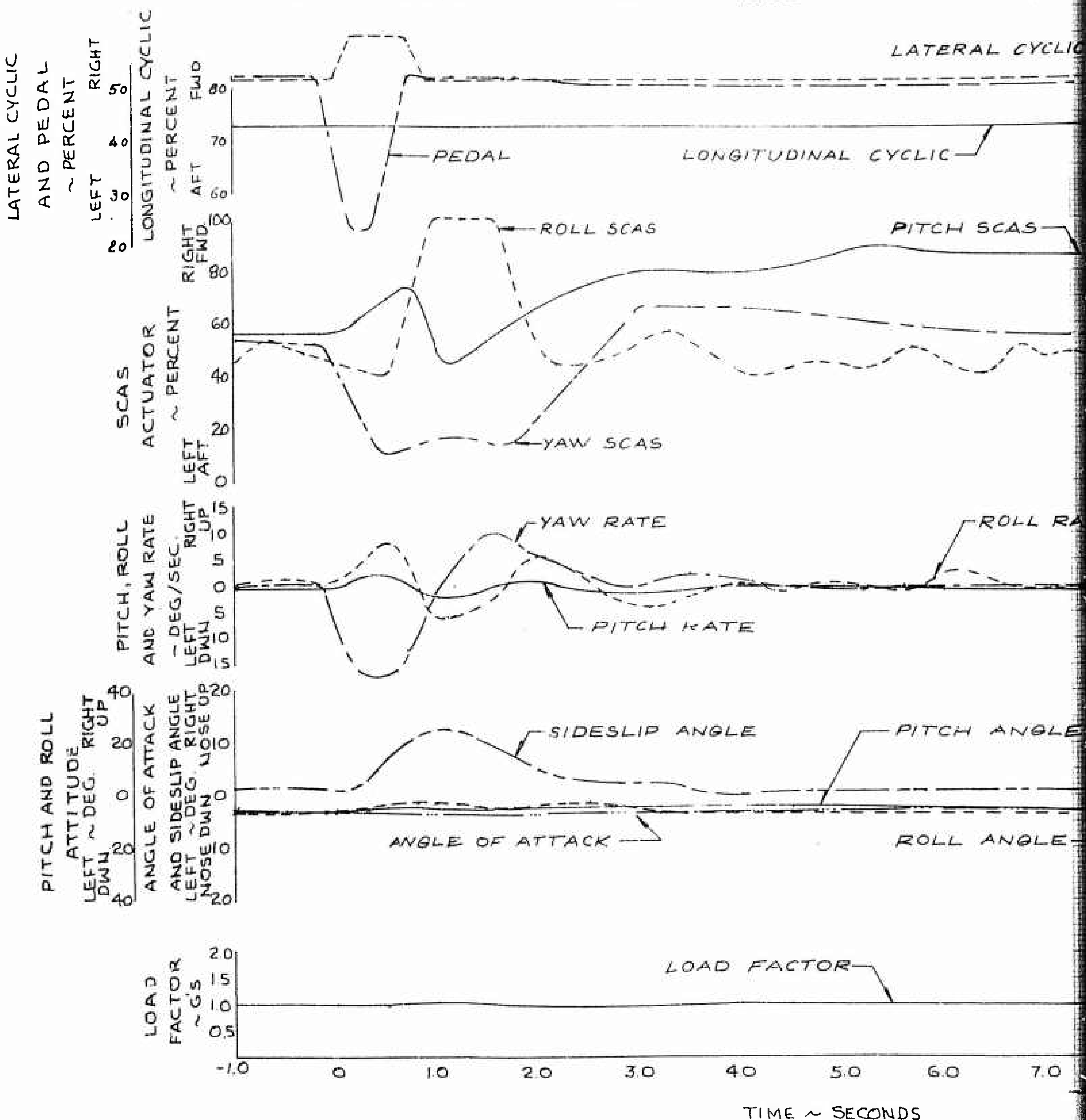


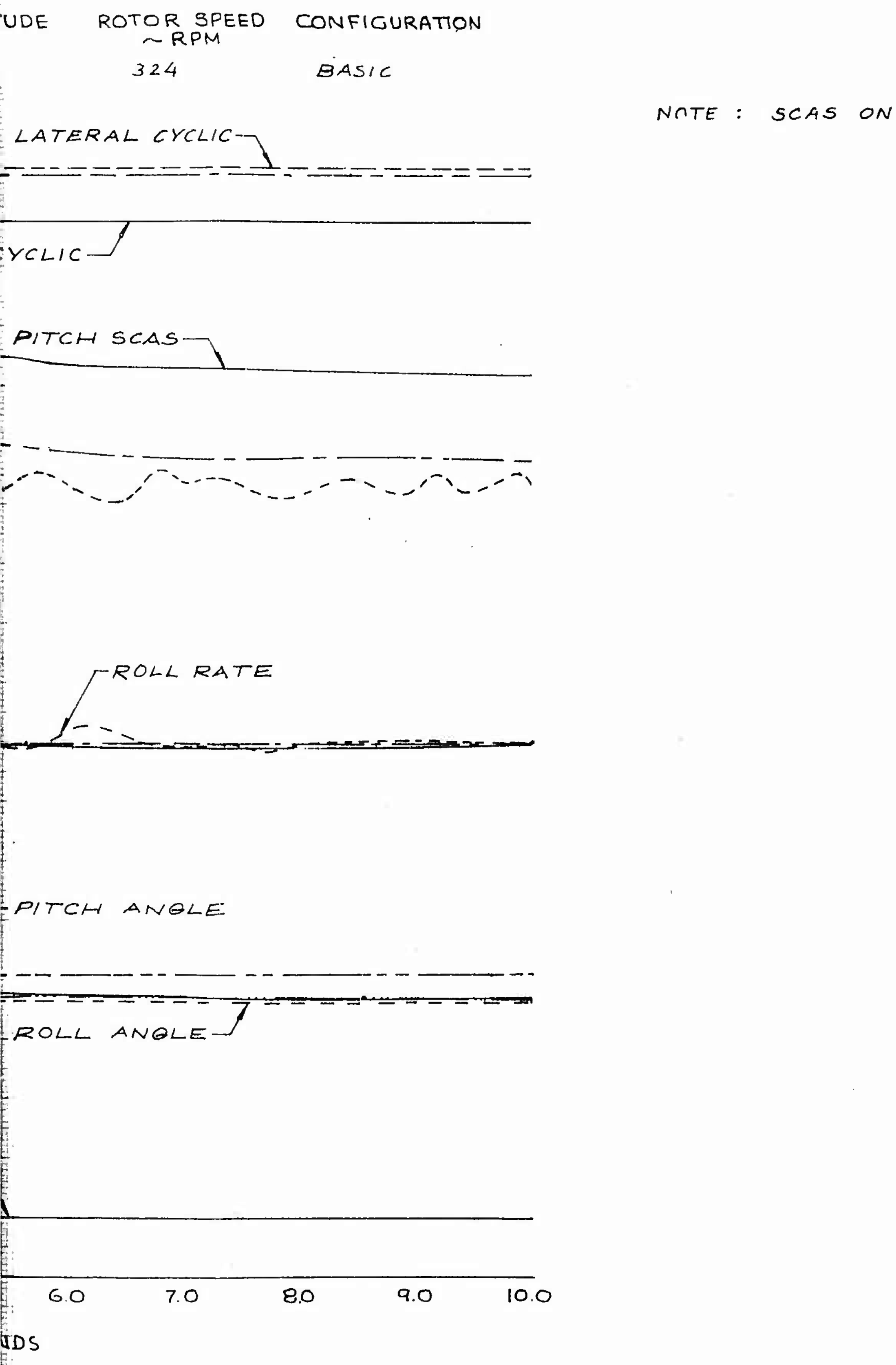
FIGURE NO. 14

LATERAL DIRECTIONAL PULSE

AH-1G USA S/N 615248

AIRSPEED ~ KCAS	GROSS WEIGHT ~ LBS.	C.G. STATION ~ IN.	DENSITY ALTITUDE ~ FT.	ROTOR SPEED ~ RPM
113	8090	197.9	4400	324





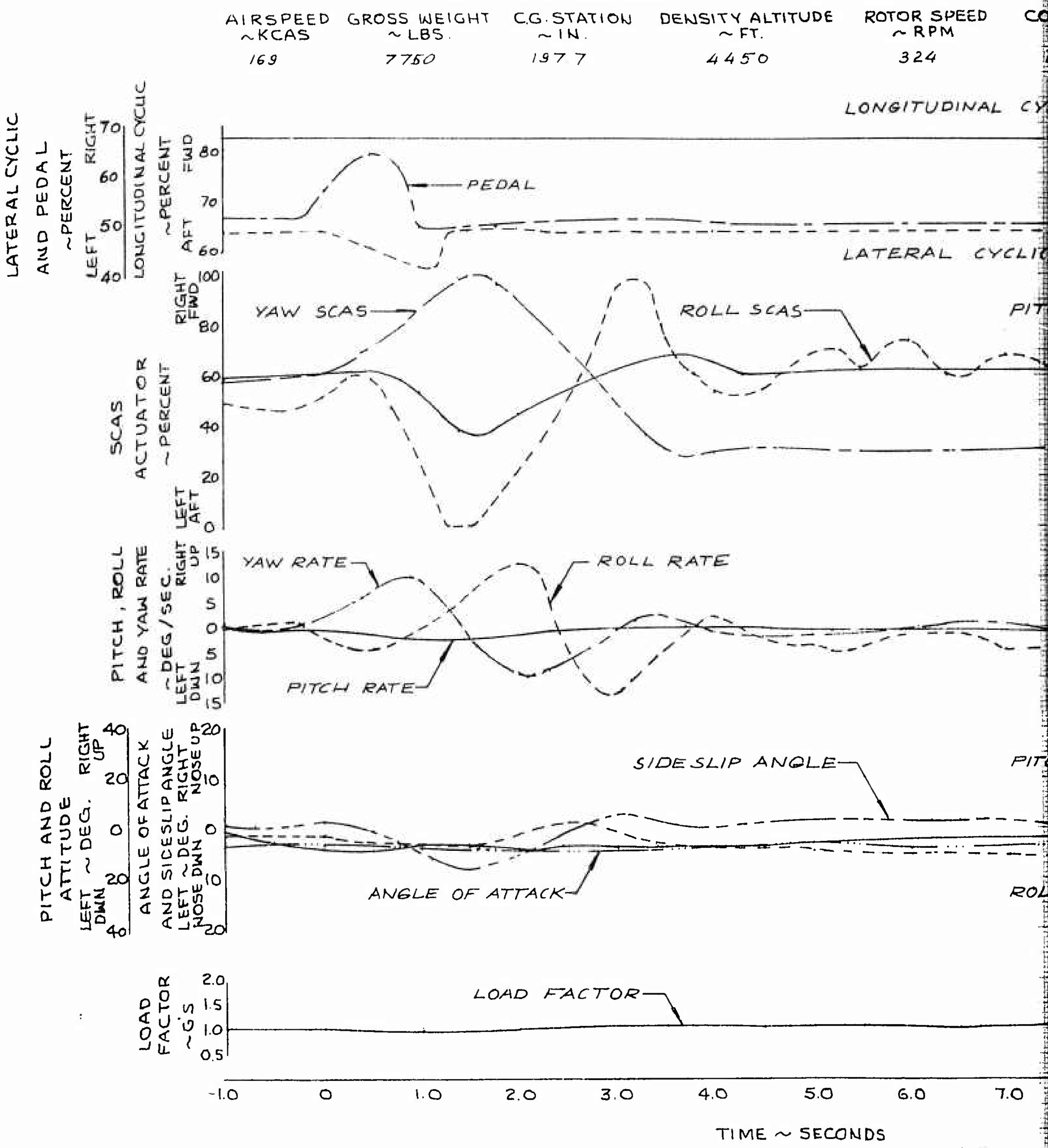
UDE
ROTOR SPEED ~ RPM
CONFIGURATION
324
BASIC
NOTE : SCAS ON
LATERAL CYCLIC
YCLIC
PITCH SCAS
ROLL RATE
PITCH ANGLE
ROLL ANGLE
6.0
7.0
8.0
9.0
10.0
NDS

2

FIGURE No. 15

LATERAL DIRECTIONAL PULSE

AH-1G USA S/N 615248



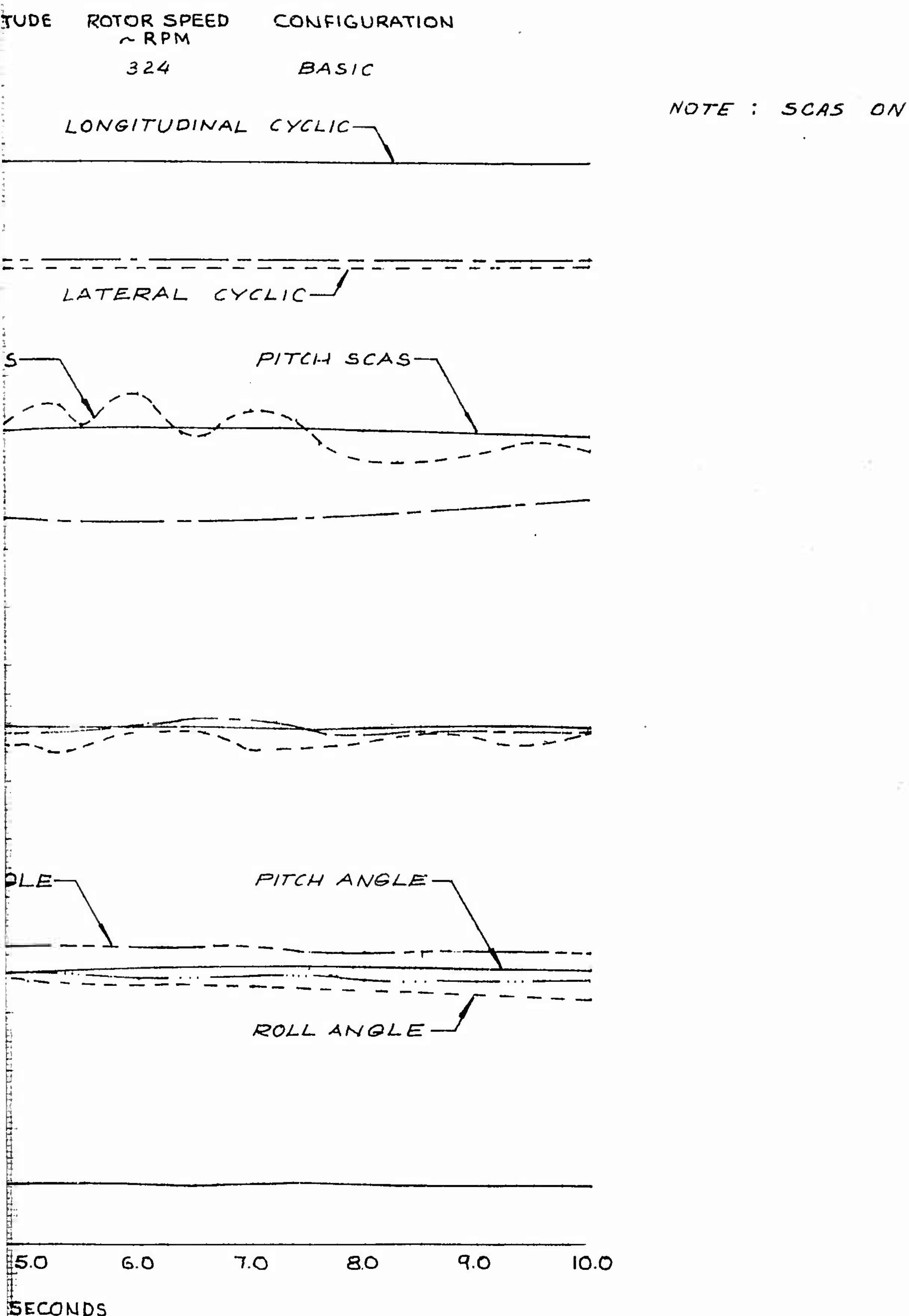
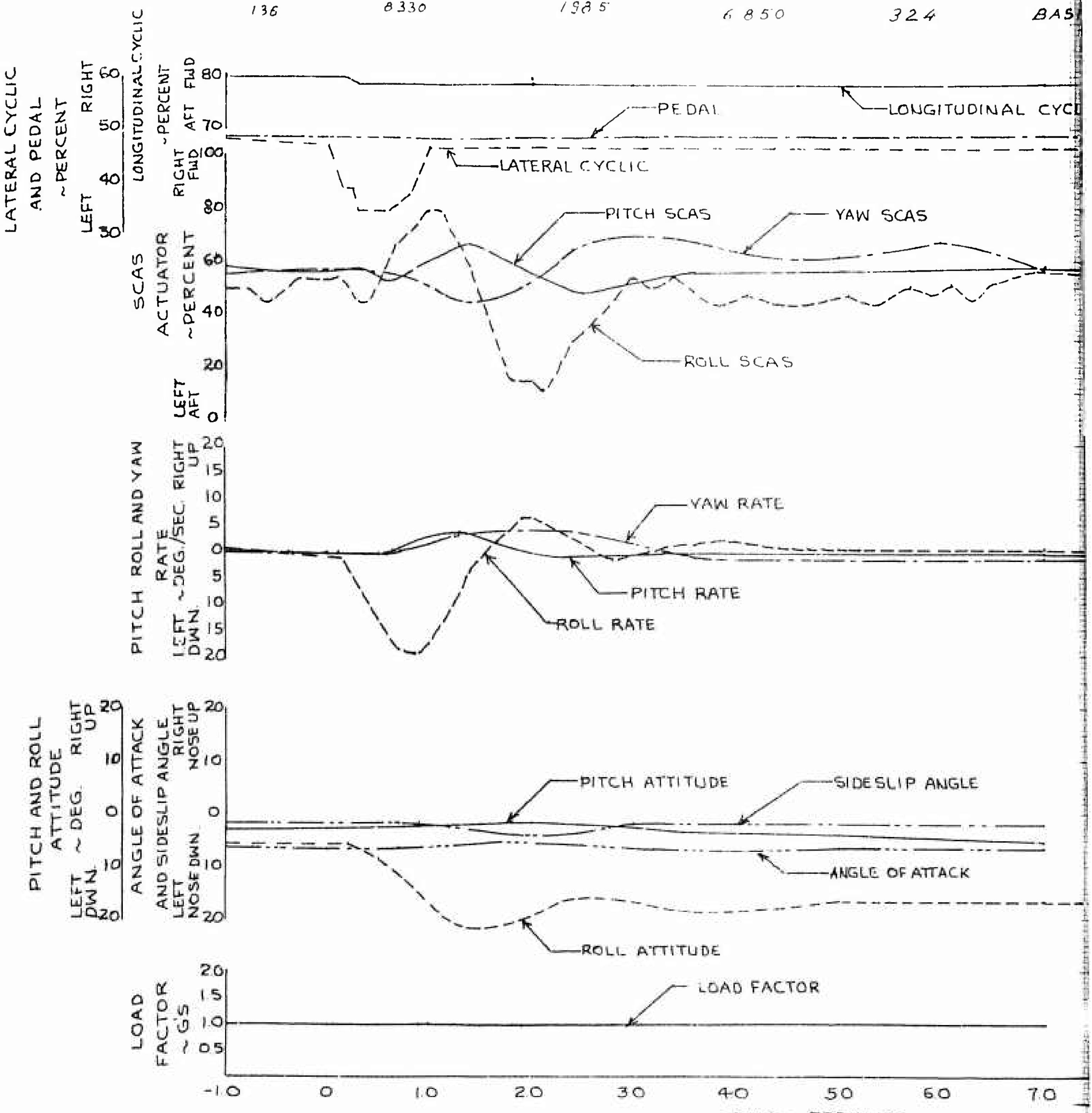

TUDE
ROTOR SPEED ~ RPM
CONFIGURATION
324
BASIC
NOTE : SCAS ON
LONGITUDINAL CYCLIC
LATERAL CYCLIC
S
PITCH SCAS
LE
PITCH ANGLE
ROLL ANGLE
5.0
6.0
7.0
8.0
9.0
10.0
SECONDS

FIGURE NO 16

LEFT LATERAL PULSE-SCAS ON

AH-1G USA S/N 615248

AIRSPEED ~ KCAS	GROSS WEIGHT ~ LBS	C.G STATION ~ IN	DENSITY ALTITUDE ~ FT	ROTOR SPEED ~ RPM	CONFI
136	8330	198.5	6850	324	BAS



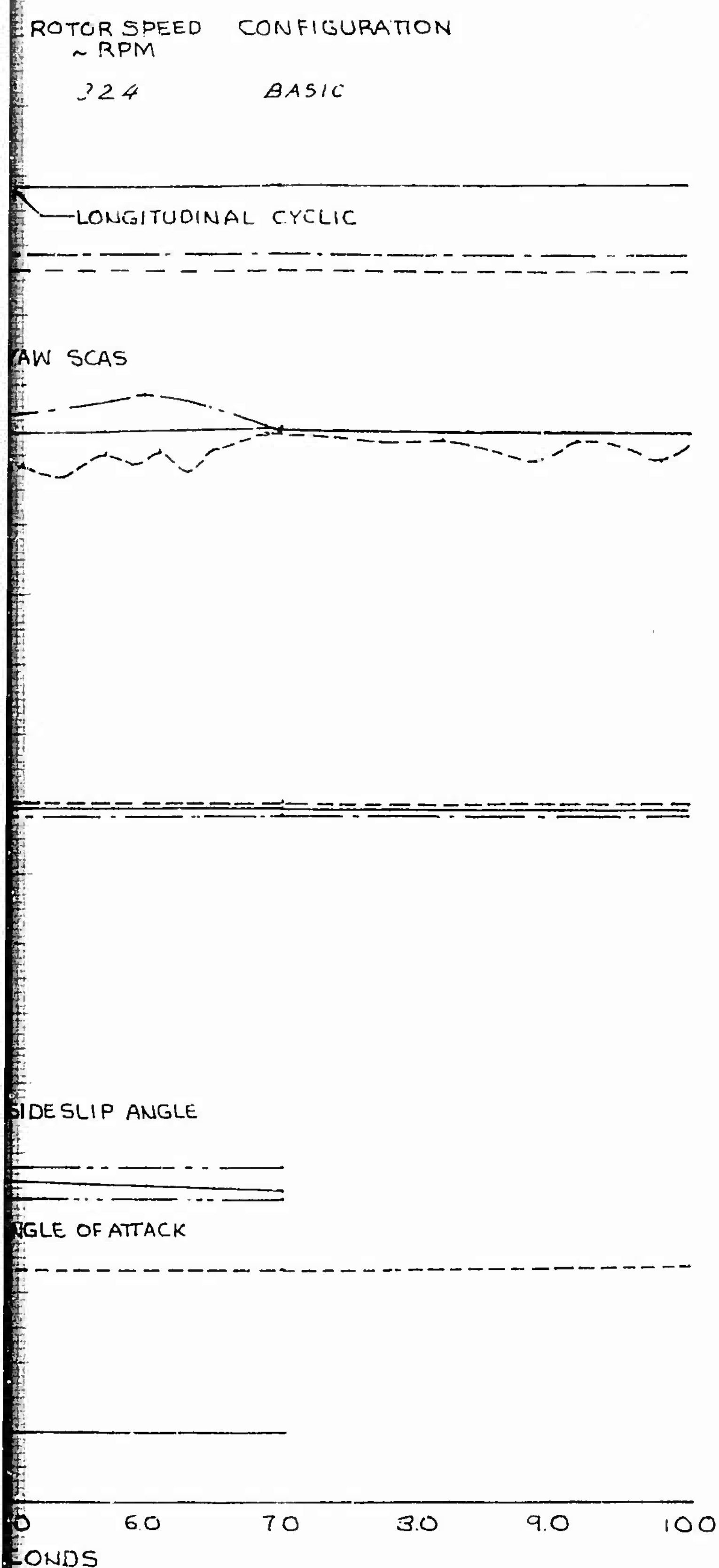
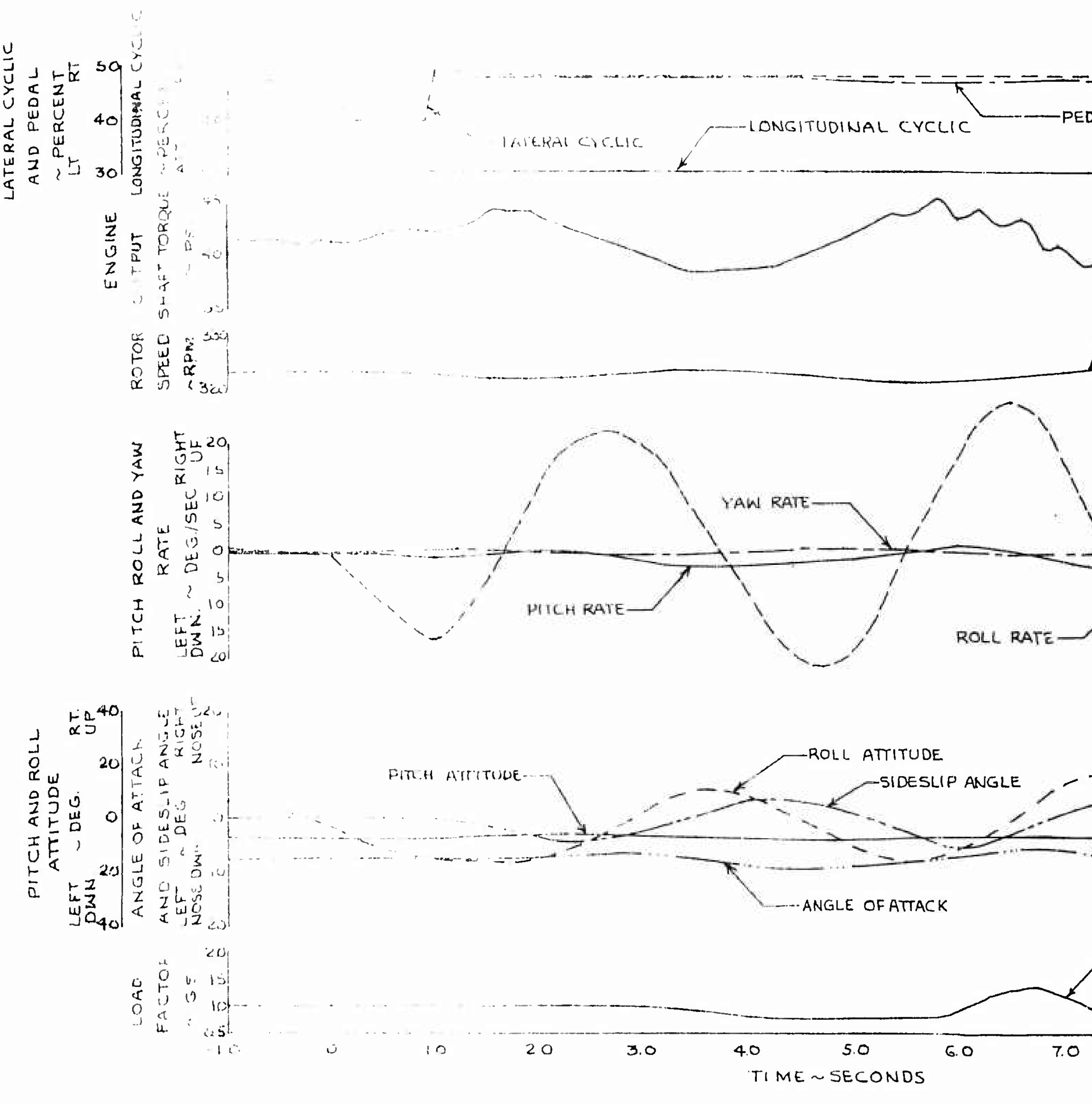

ROTOR SPEED ~ RPM
CONFIGURATION
324
BASIC
LONGITUDINAL CYCLIC
YAW SCAS
SIDESLIP ANGLE
NGLE OF ATTACK
0
60
70
80
90
100
ONDS

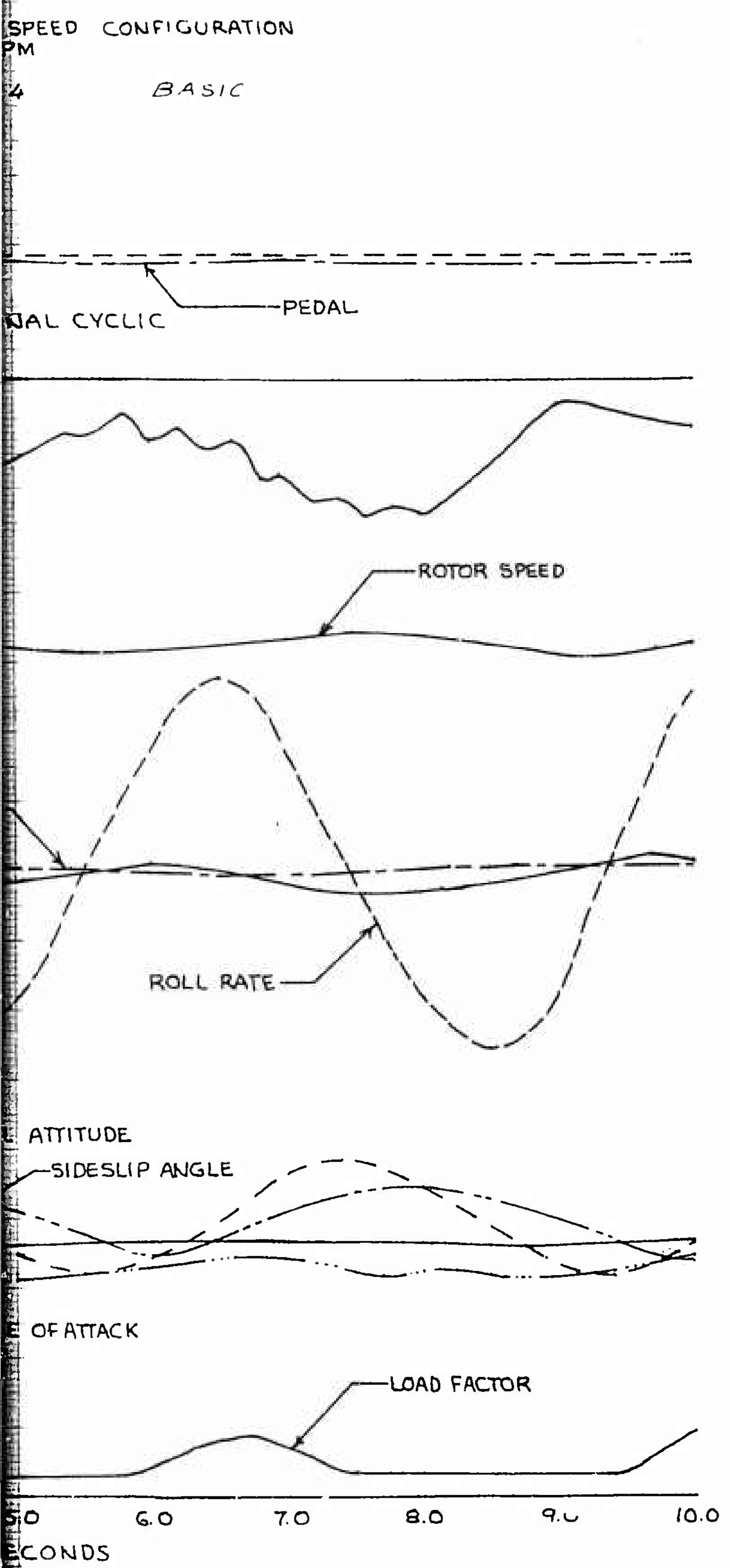
FIGURE NO 17

[illegible] LATERAL PULSE - SCAS OFF

[illegible] USA S/N 615248

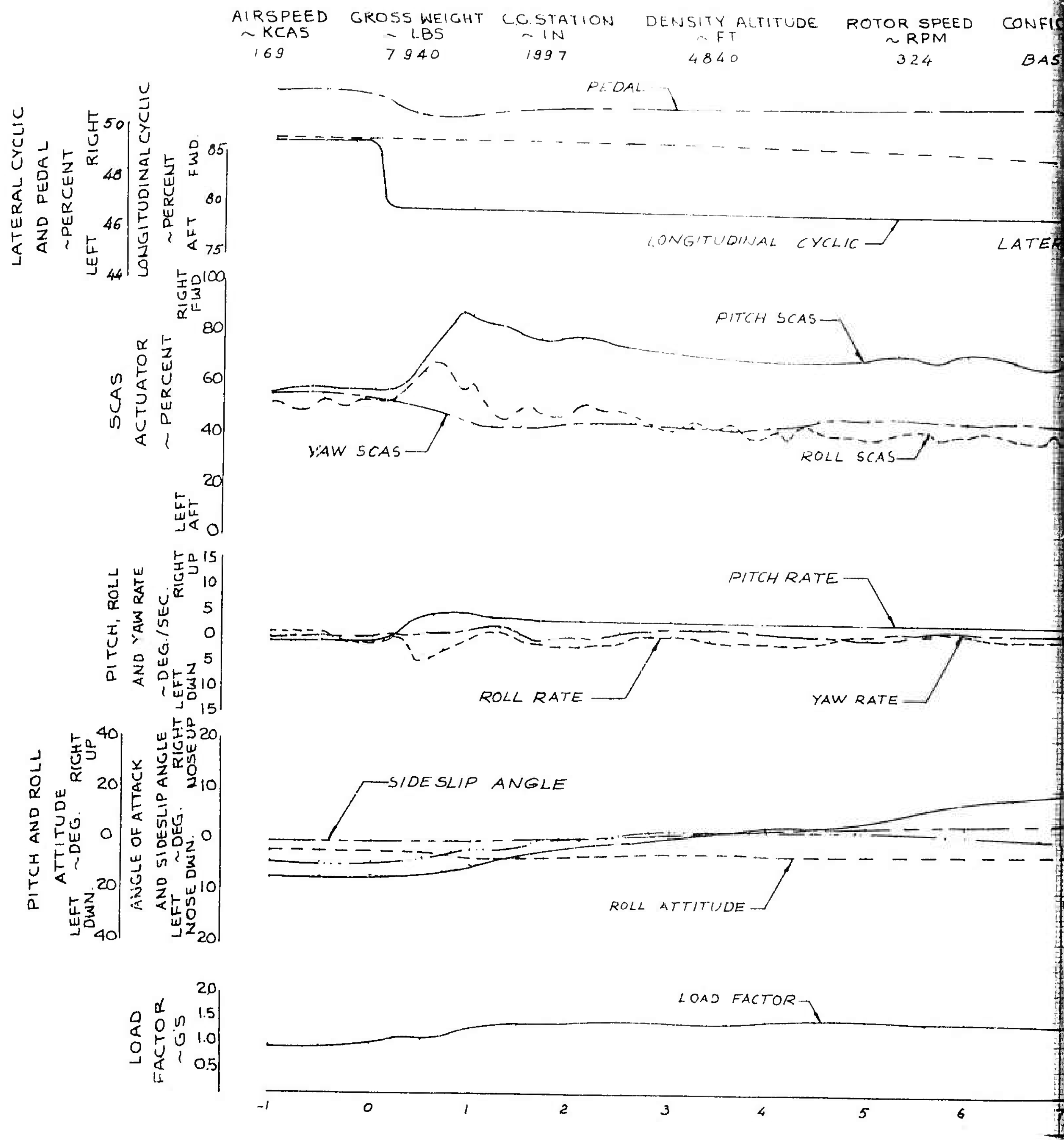
[illegible]	WEIGHT ~LBS	C G STATION ~IN	DENSITY ALT ~FT	ROTOR SPEED ~RPM	CONFIGURATION
[illegible]	[illegible]	197.9	7300	324	BASIC




SPEED CONFIGURATION
PM
4 BASIC
PEDAL
AL CYCLIC
ROTOR SPEED
ROLL RATE
ATTITUDE
SIDESLIP ANGLE
OF ATTACK
LOAD FACTOR
6.0
7.0
8.0
10.0
CONDS

2

FIGURE NO 18
AFT LONGITUDINAL STEP
AH-1G USA S/N 615248



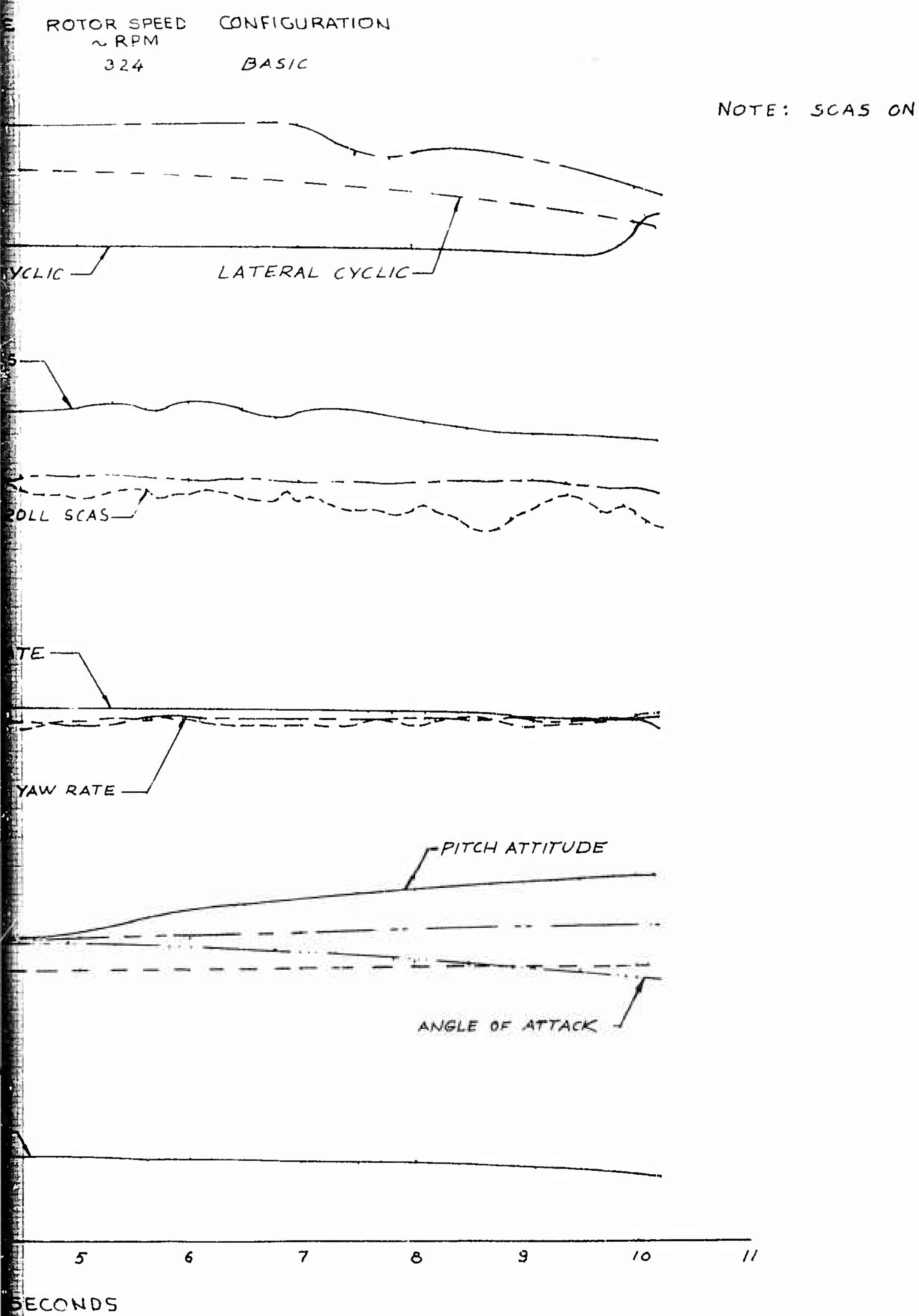

ROTOR SPEED ~ RPM
324
CONFIGURATION
BASIC
NOTE: SCAS ON
YCLIC
LATERAL CYCLIC
ROLL SCAS
TE
YAW RATE
PITCH ATTITUDE
ANGLE OF ATTACK
5
6
7
8
9
10
11
SECONDS

FIGURE No. 19

LONGITUDINAL RESPONSE

AH-1G USA S/N 615248

AVE. C.G. STATION ~ IN.	AVE. DENSITY ALTITUDE ~ FT.	ROTOR SPEED ~ RPM	CONFIGURATION
191.9	5150	324	BASIC

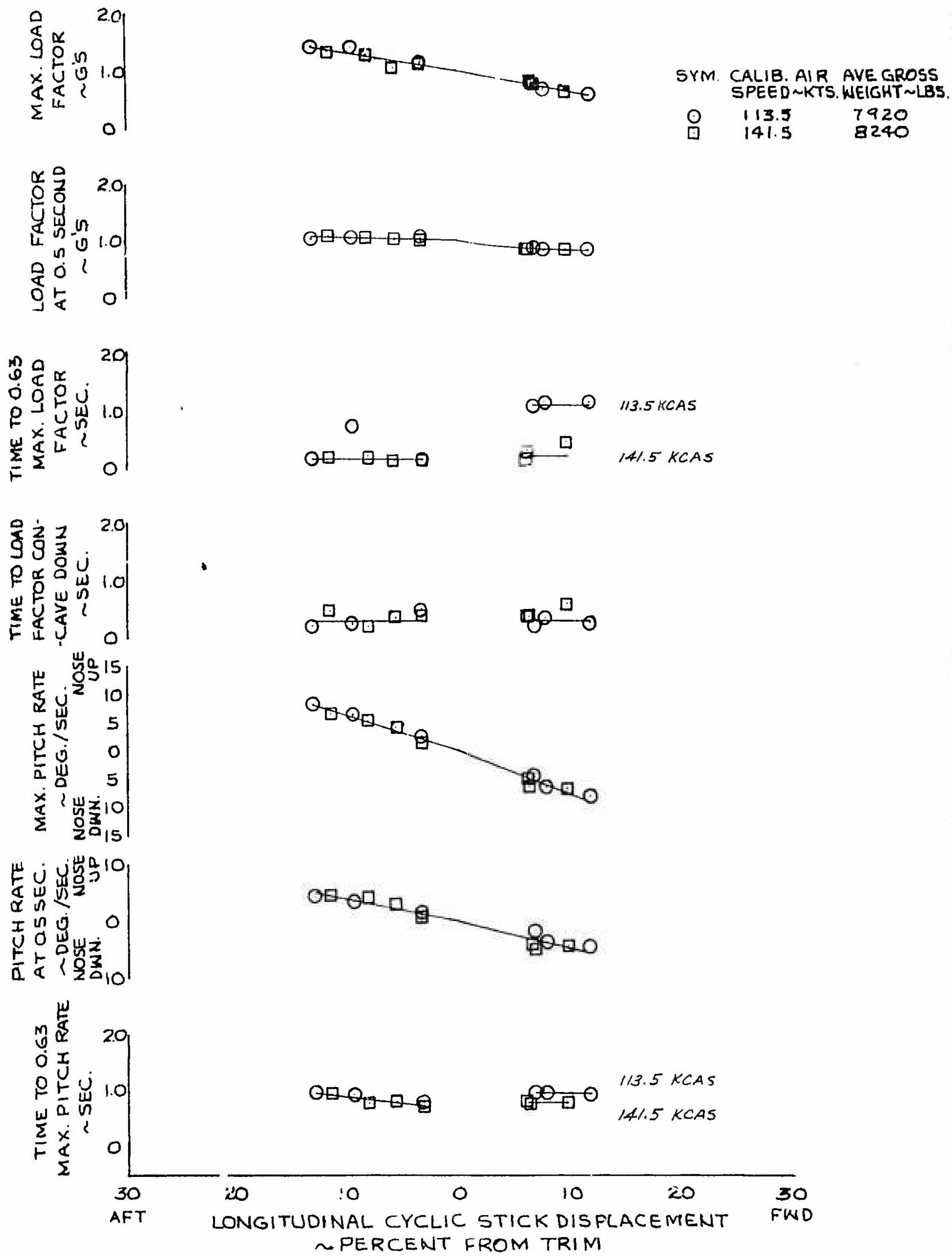


FIGURE NO. 20

LONGITUDINAL RESPONSE

AH-1G USA S/N 615248

AVE C.G. STATION ~ IN	AVE DENSITY ALTITUDE ~ FT.	ROTOR SPEED ~ RPM	CONFIGURATION
199.6	4720	324	BASIC

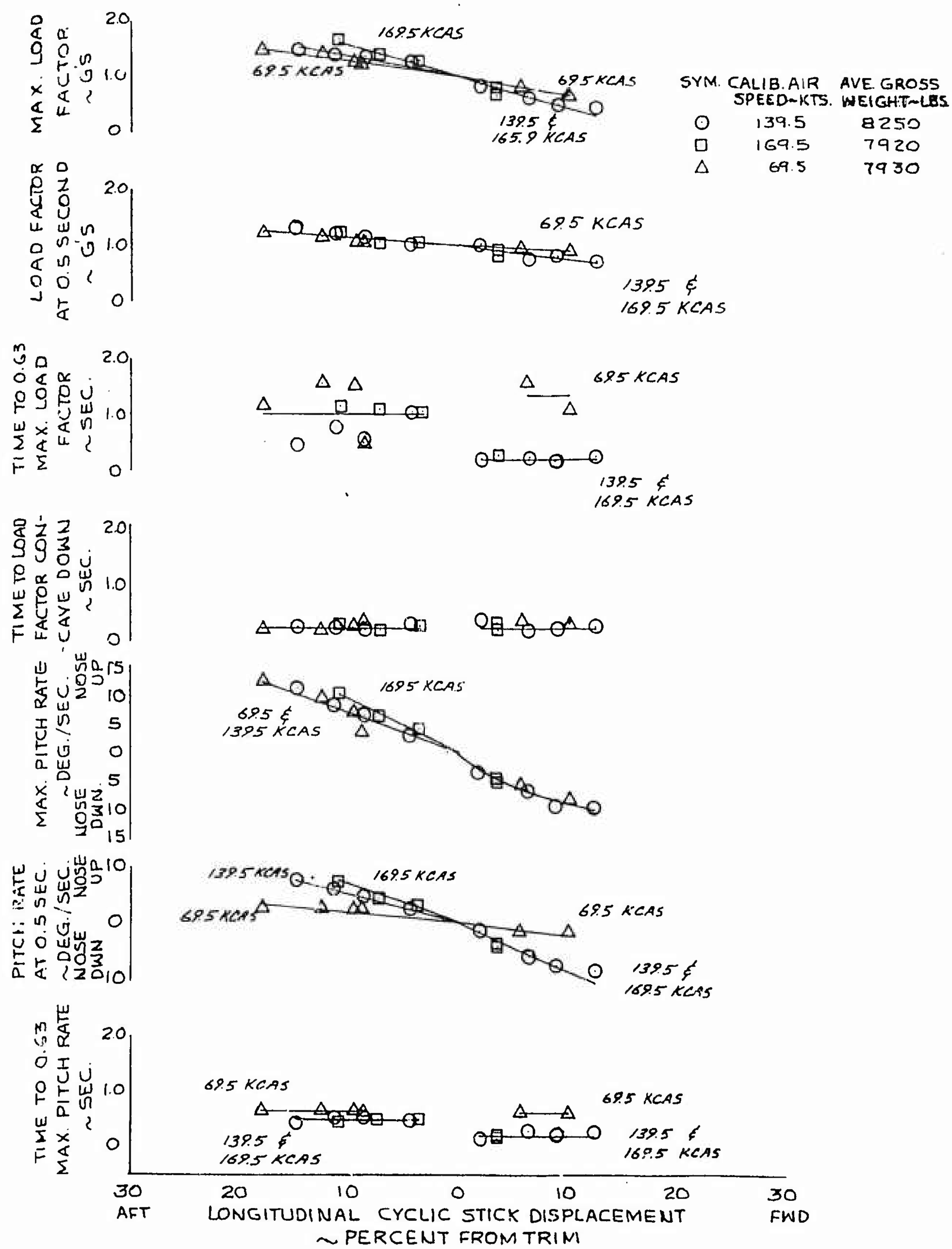
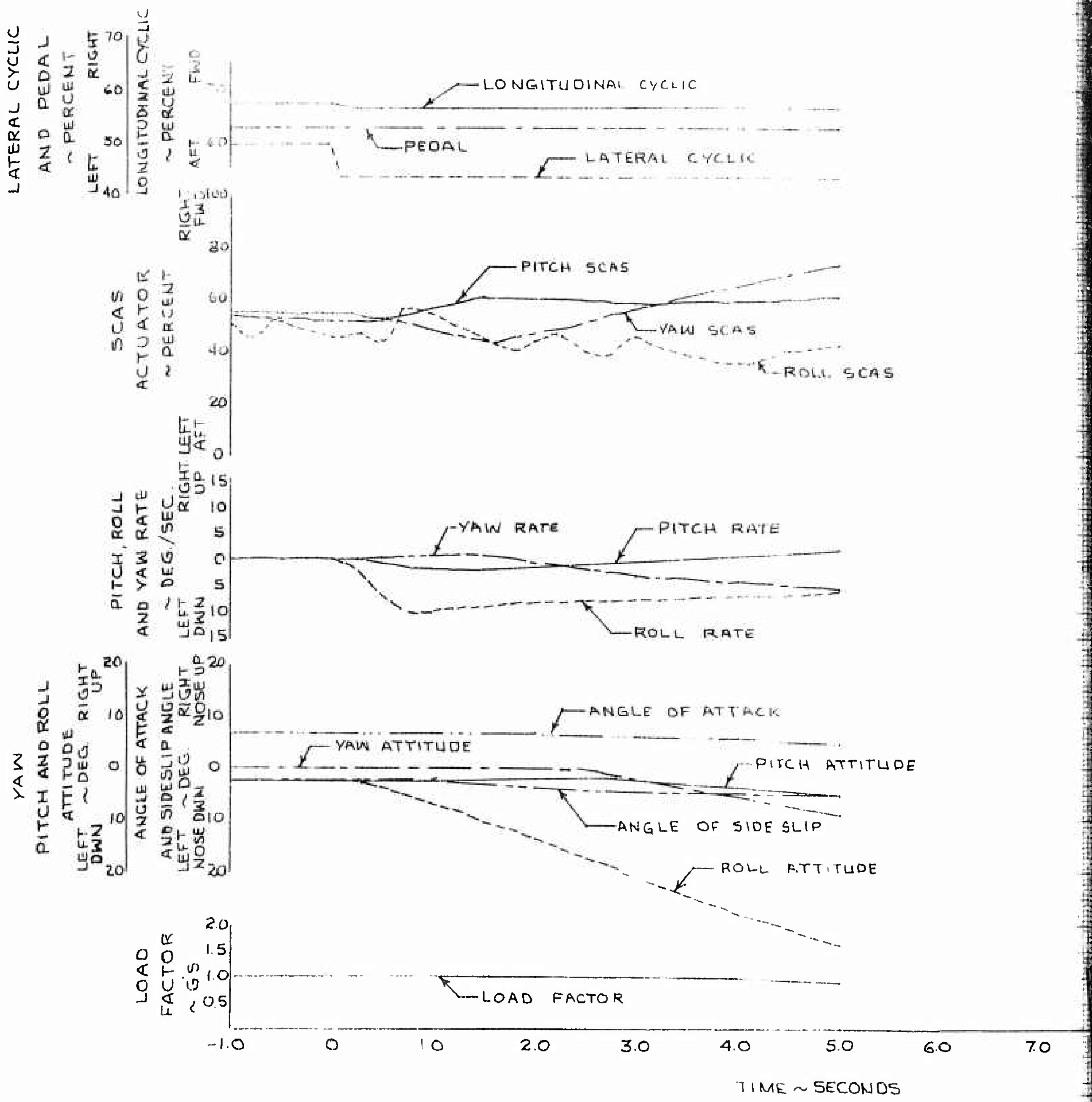


FIGURE NO 21

LEFT LATERAL STEP

AH-1G USA S/N 615248

AIRSPEED ~ KCAS	GROSS WEIGHT ~ LBS	C.G STATION ~ IN	DENSITY ALTITUDE FT	ROTOR SPEED ~ RPM	CONF
70	8035	199.8	5500	324	



ROTOR SPEED ~RPM

324

CONFIGURATION

BASIC

NOTE : SCAS ON

SCAS

TITUDE

UDE

6.0 7.0 8.0 9.0 10.0

ONDS

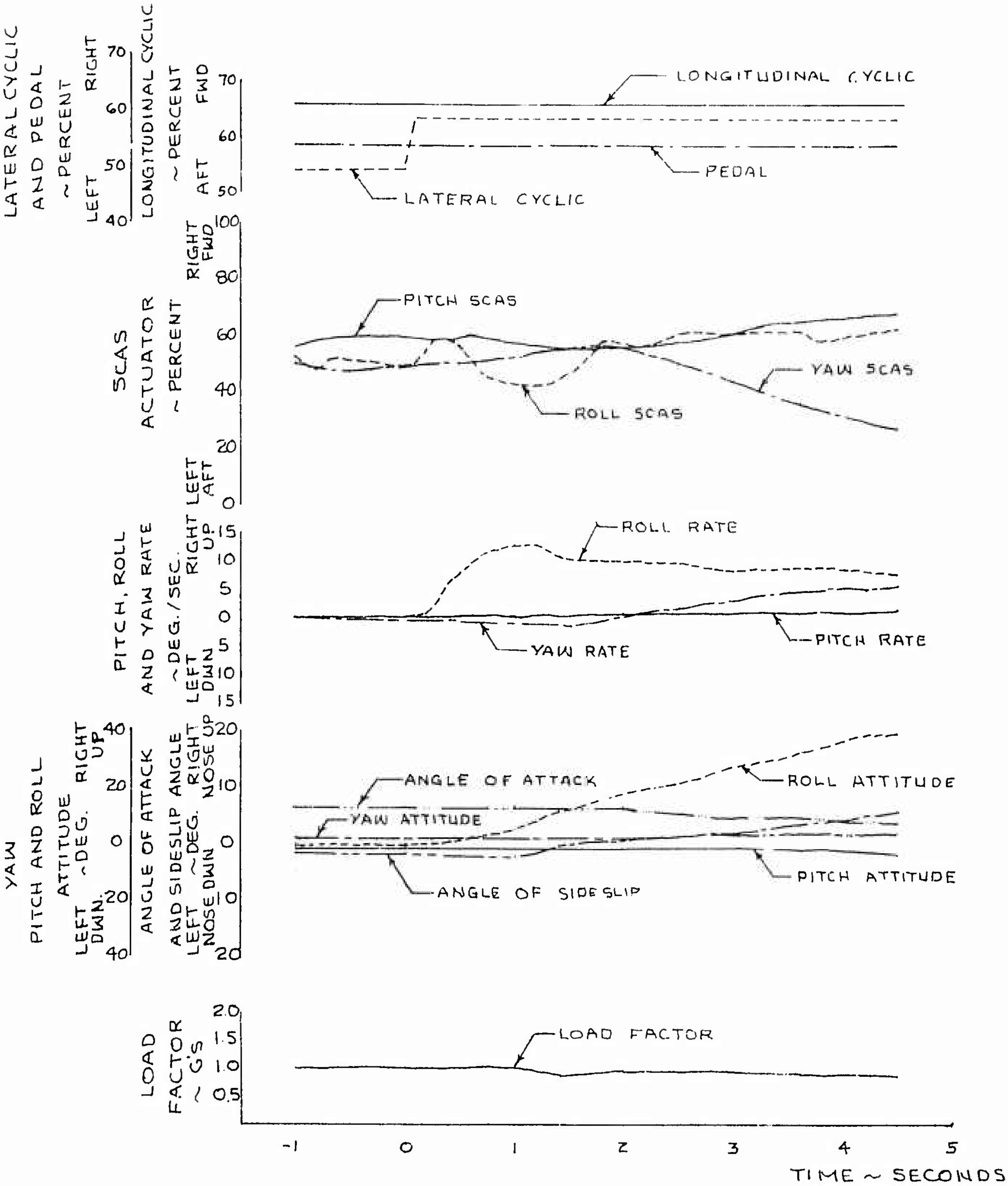
2

FIGURE NO 22

RIGHT LATERAL STEP

AH-1G USA S/N 615248

AIRSPEED ~KCAS	GROSS WEIGHT ~ LBS	CG STATION ~ IN	DENSITY ALTITUDE ~ FT	ROTOR SPEED ~ RPM
70	8020	199.8	5500	324



DE ROTOR SPEED CONFIGURATION
~ RPM
324 BASIC

NOTE : SCAS ON

IC

AS

ATE

TUDE

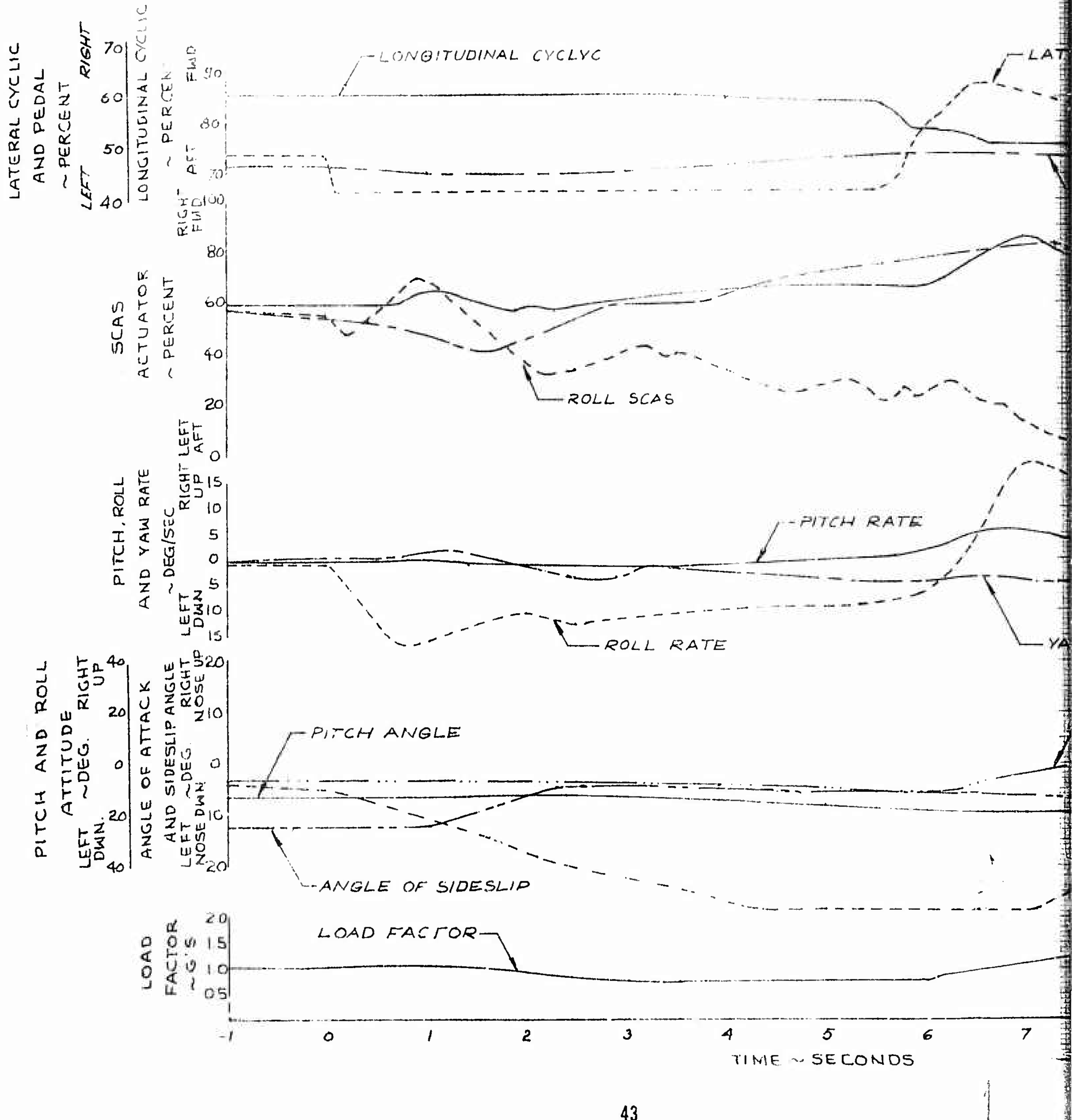
TUDE

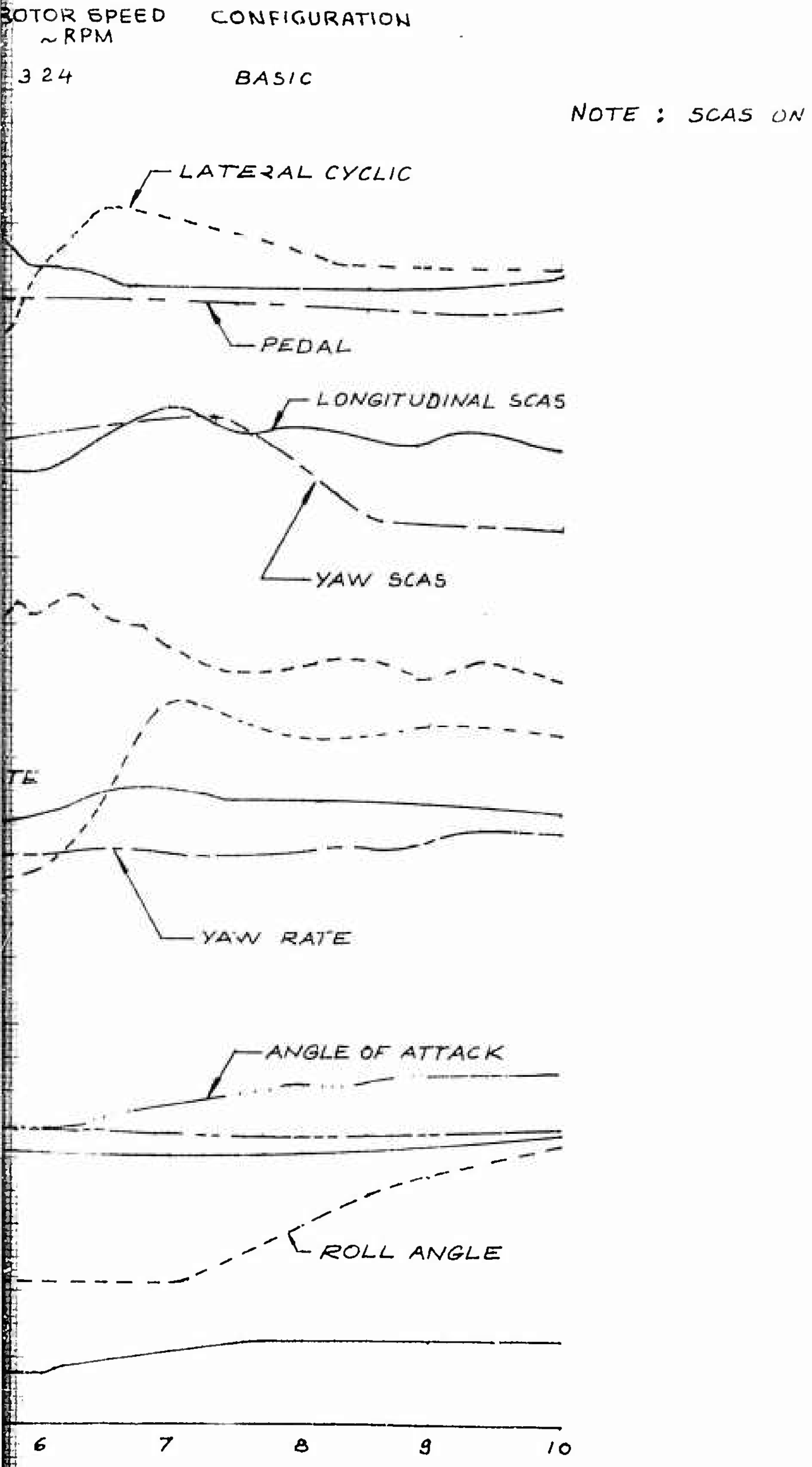
5
SECONDS

2

Figure No 23
Left Lateral Step
AH-1G USA S/N 615248

AIRSPEED ~KCAS	GROSS WEIGHT ~LBS	C.G STATION ~IN.	DENSITY ALTITUDE ~FT	ROTOR SPEED ~RPM
169	8 030	188.8	4 840	324





ROTOR SPEED ~RPM
CONFIGURATION
3 24
BASIC
NOTE : SCAS ON
LATERAL CYCLIC
PEDAL
LONGITUDINAL SCAS
YAW SCAS
YAW RATE
ANGLE OF ATTACK
ROLL ANGLE
6
7
8
9
10

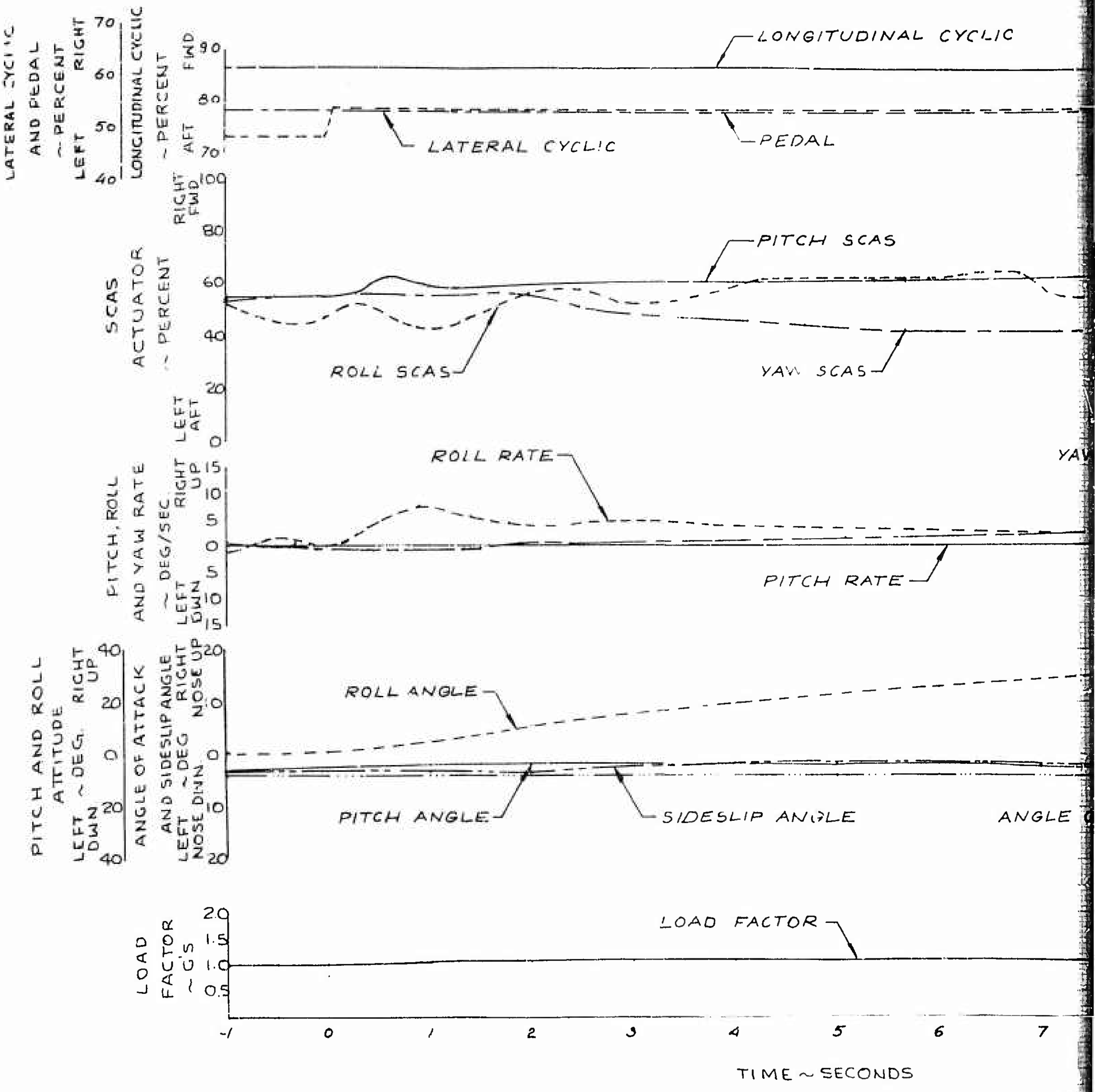
2

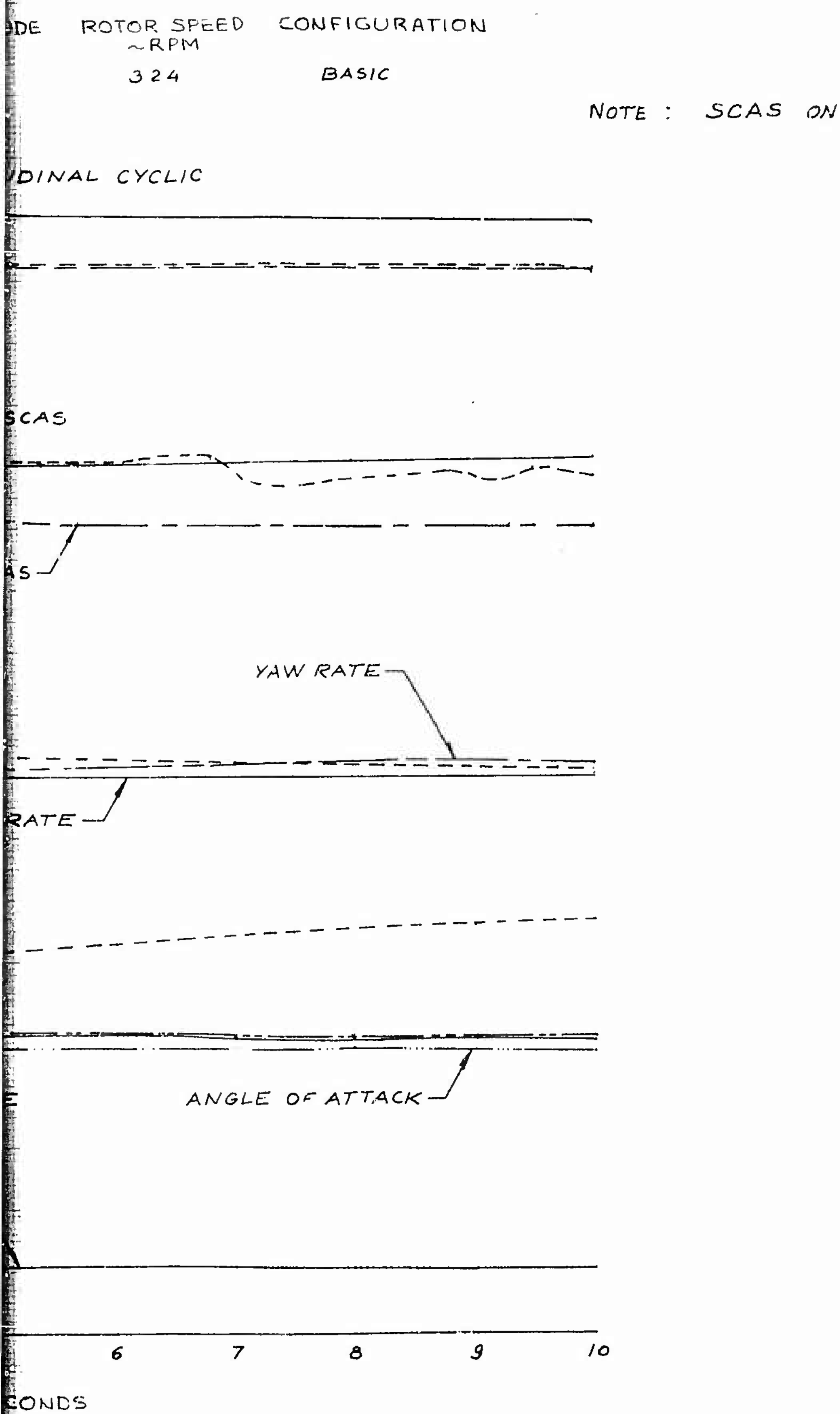
FIGURE NO 24

RIGHT LATERAL STEP

AH-1G USA S/N 615248

AIRSPEED ~KCAS	GROSS WEIGHT ~LBS	C.G. STATION ~IN	DENSITY ALTITUDE ~FT.	ROTOR SPEED ~RPM
169	8005	199.6	4840	324





DE
ROTOR SPEED ~RPM
CONFIGURATION
324
BASIC
NOTE : SCAS ON
DINAL CYCLIC
SCAS
AS
YAW RATE
RATE
ANGLE OF ATTACK
6
7
8
9
10
CONDS

2

FIGURE No 25

LATERAL RESPONSE

AH-1G USA S/N 615 248

AIRSPEED ~KCAS	GROSS WEIGHT ~LBS	C.G STATION ~IN.	DENSITY ALTITUDE ~FT	ROTOR SPEED ~RPM	CONFIGURATION
70.5	8 015	199.8	5 610	324	BASIC

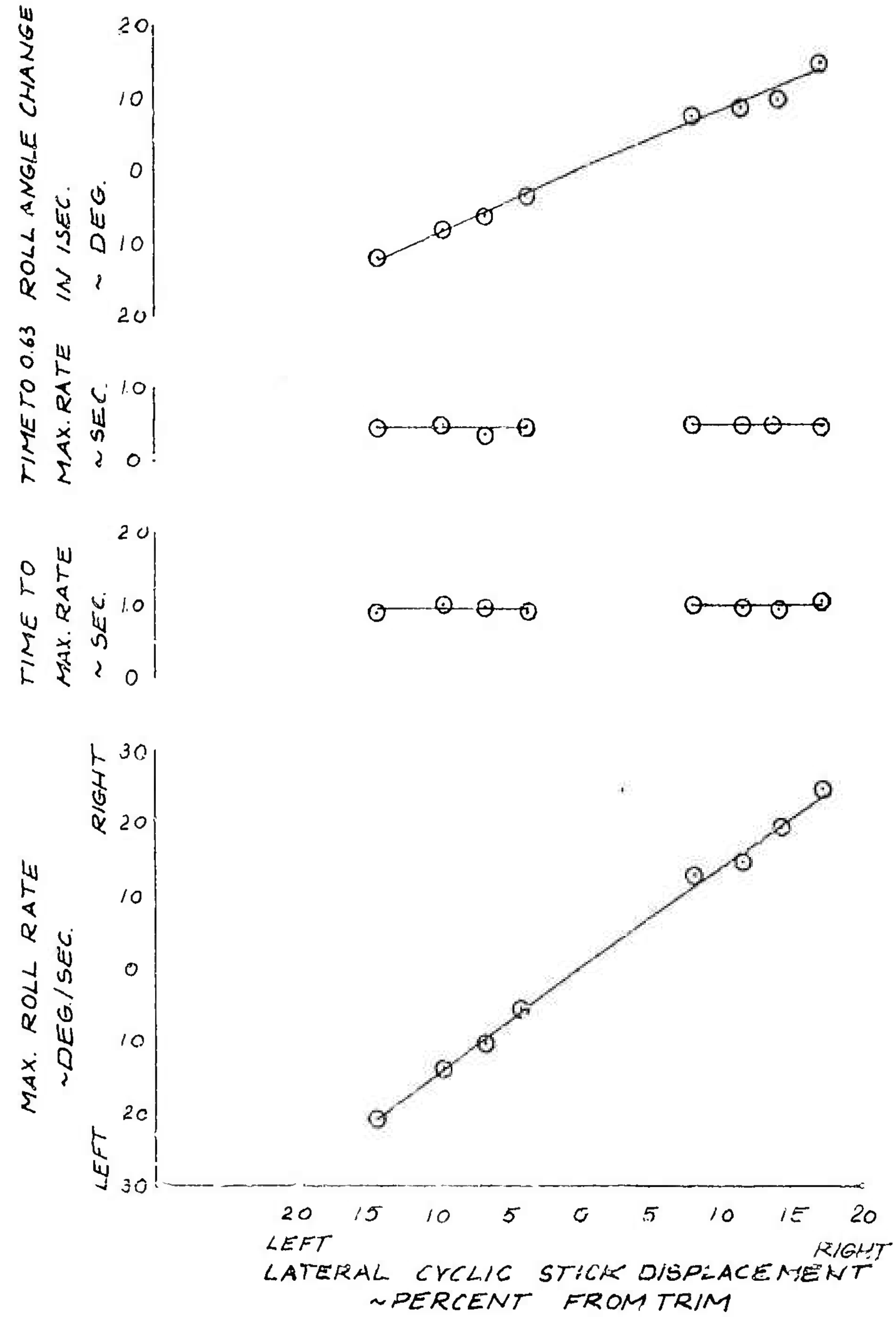


FIGURE NO. 2F
LATERAL RESPONSE
AH-1G USA S/N 615248

SYM	AIRSPEED ~KCAS	GROSS WEIGHT ~LBS	C.G. STATION ~IN	DENSITY ALTITUDE ~FT	ROTOR SPEED ~RPM	CONFIGURATION
○	113.5	8050	191.7	5150	324	BASIC
□	141.5	8380	192	5150	324	BASIC

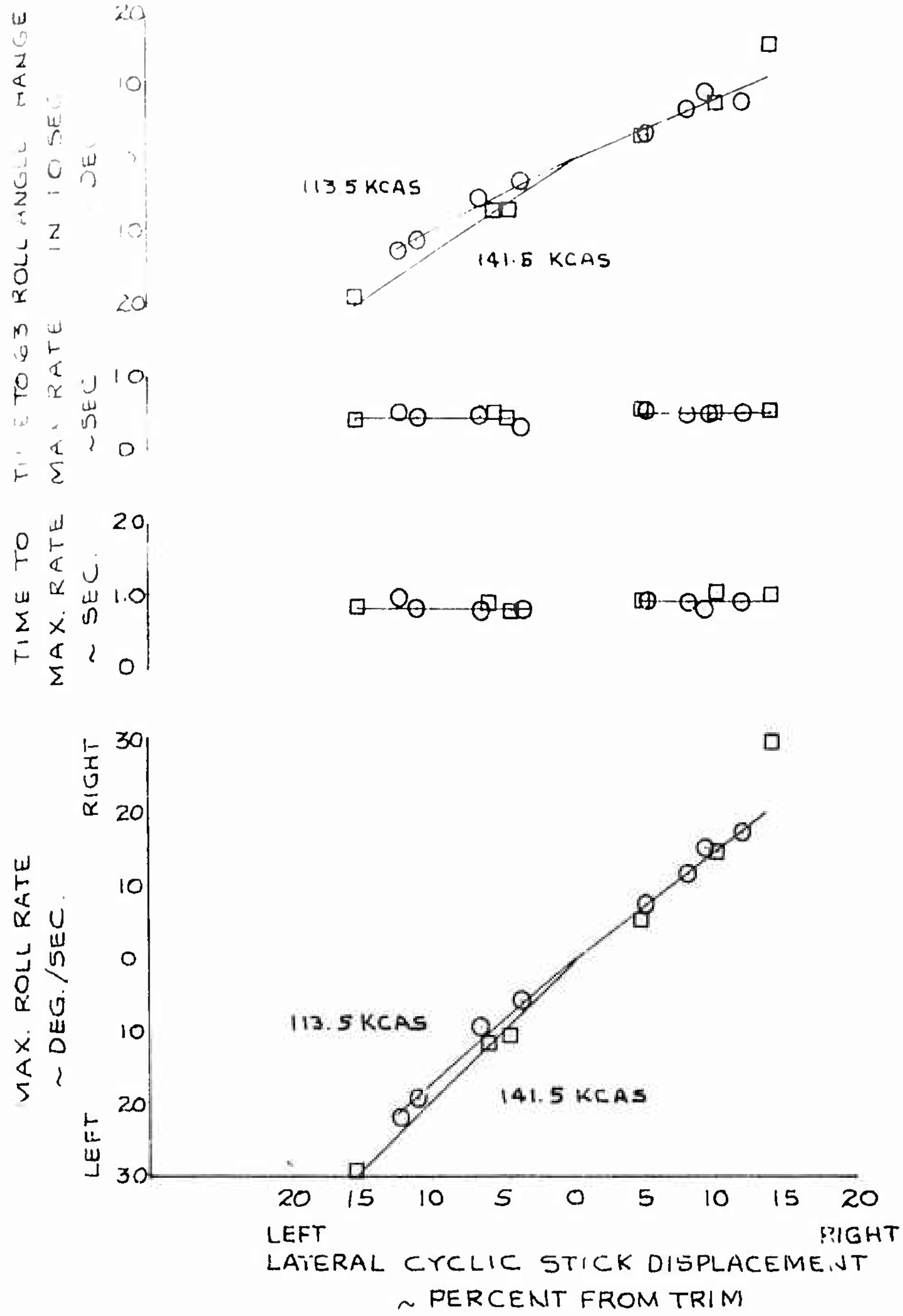


FIGURE No 27

LATERAL RESPONSE

AH 1G USA S/N 615 248

SYMBOL	AIRSPEED ~KCAS	GROSS WEIGHT ~LBS	C.G STATION ~IN	DENSITY ALTITUDE ~FT	ROTOR SPEED ~RPM	CONFIGURATION
○	135.5	8375	198.0	7110	324	BASIC
△	70.5	7990	198.	7290	324	BASIC
□	169.0	8030	199.	4800	324	BASIC

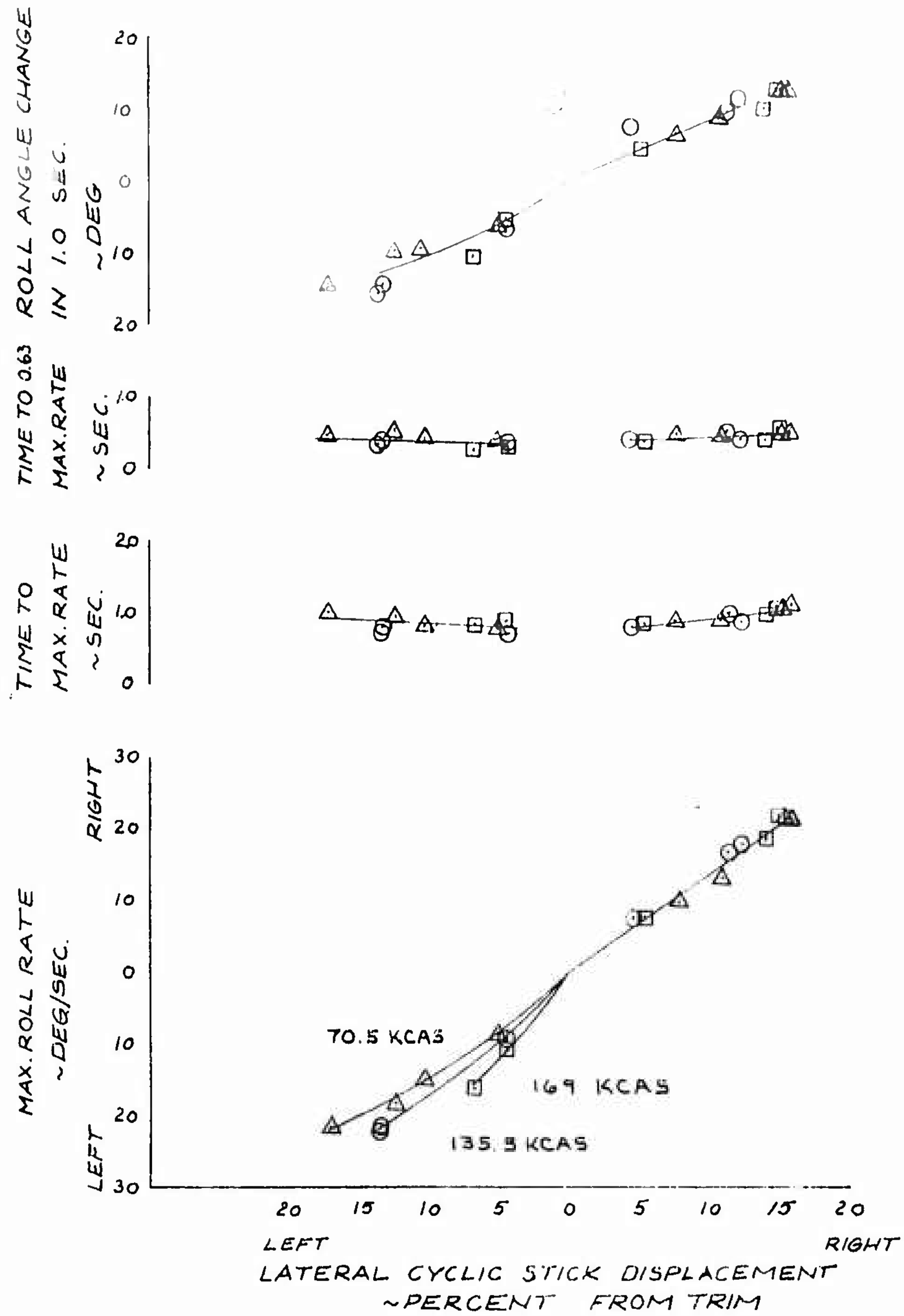


FIGURE NO 28

MANEUVERING STABILITY

AH-1G USA S/N 615248

AIRSPEED ~ KCAS	GROSS WEIGHT ~ LBS	C.G STATION ~ IN.	DENSITY ALTITUDE ~ FT	ROTOR SPEED ~ RPM	CONFIGURATION
112.5	7920	191.4	5050	324	BASIC

NOTES:

1. DATA OBTAINED BY SYMETRICAL PULL-UP METHOD.
2. CYCLIC FORCE TRIM ON.
3. CYCLIC FRICTION SET AT CONTRACTOR RECOMMENDED VALUE.
4. LONGITUDINAL CYCLIC STICK FORCE MEASURED AT CENTER OF HAND GRIP.

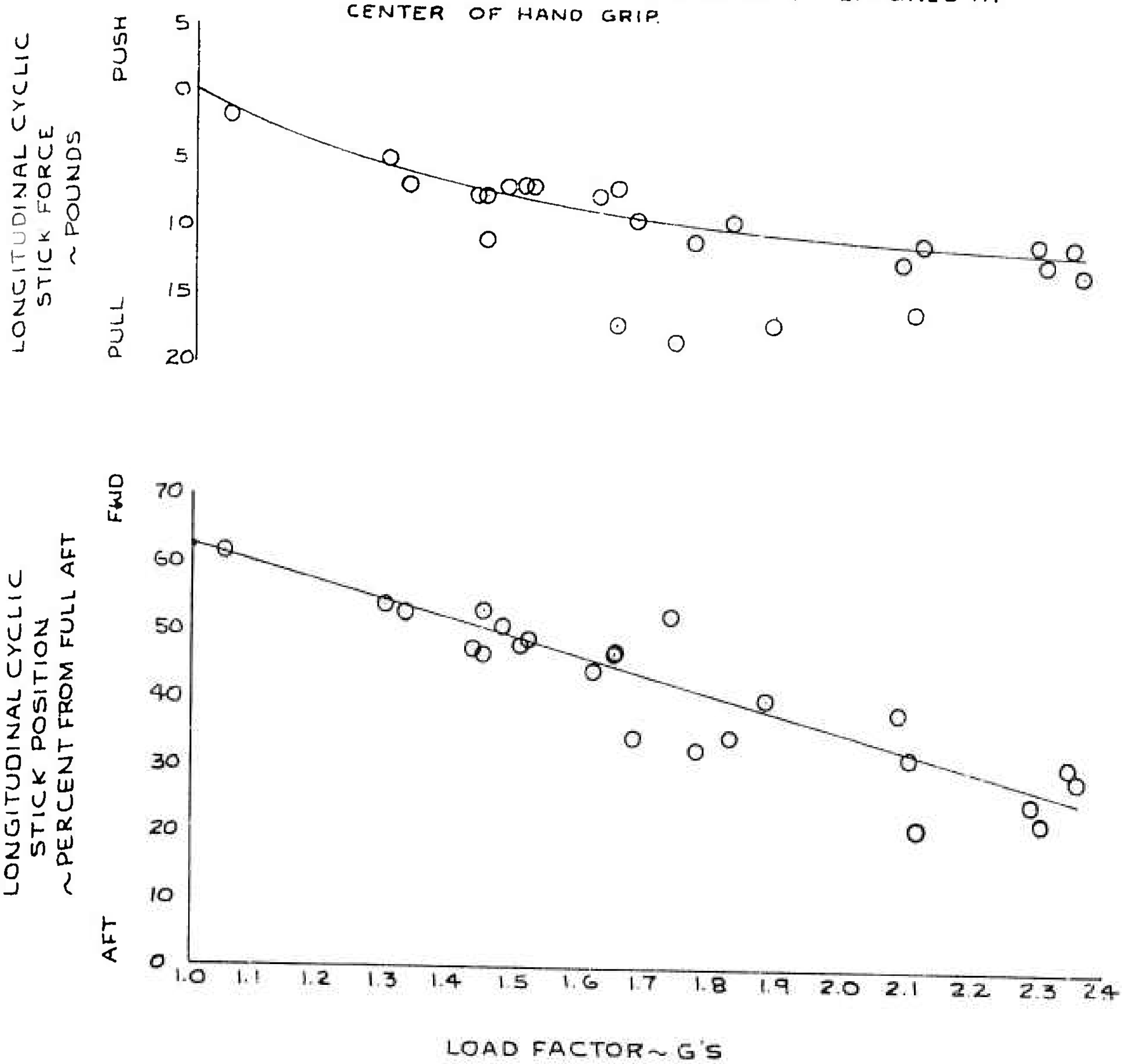


FIGURE No. 29

MANEUVERING STABILITY

AH-1G USA S/N 615248

AIRSPEED ~ KCAS	GROSS WEIGHT ~ LBS.	C.G. STATION ~ IN.	DENSITY ALTITUDE ~ FT	ROTOR SPEED ~ RPM	CONFIGURATION
168	8360	192.1	4750	324	BASIC

NOTES:

1. DATA OBTAINED BY SYMETRICAL PULL-UP METHOD.
2. CYCLIC FORCE TRIM ON.
3. CYCLIC FRICTION SET AT CONTRACTOR RECOMMENDED VALUE.
4. LONGITUDINAL CYCLIC STICK FORCE MEASURED AT CENTER OF HAND GRIP.

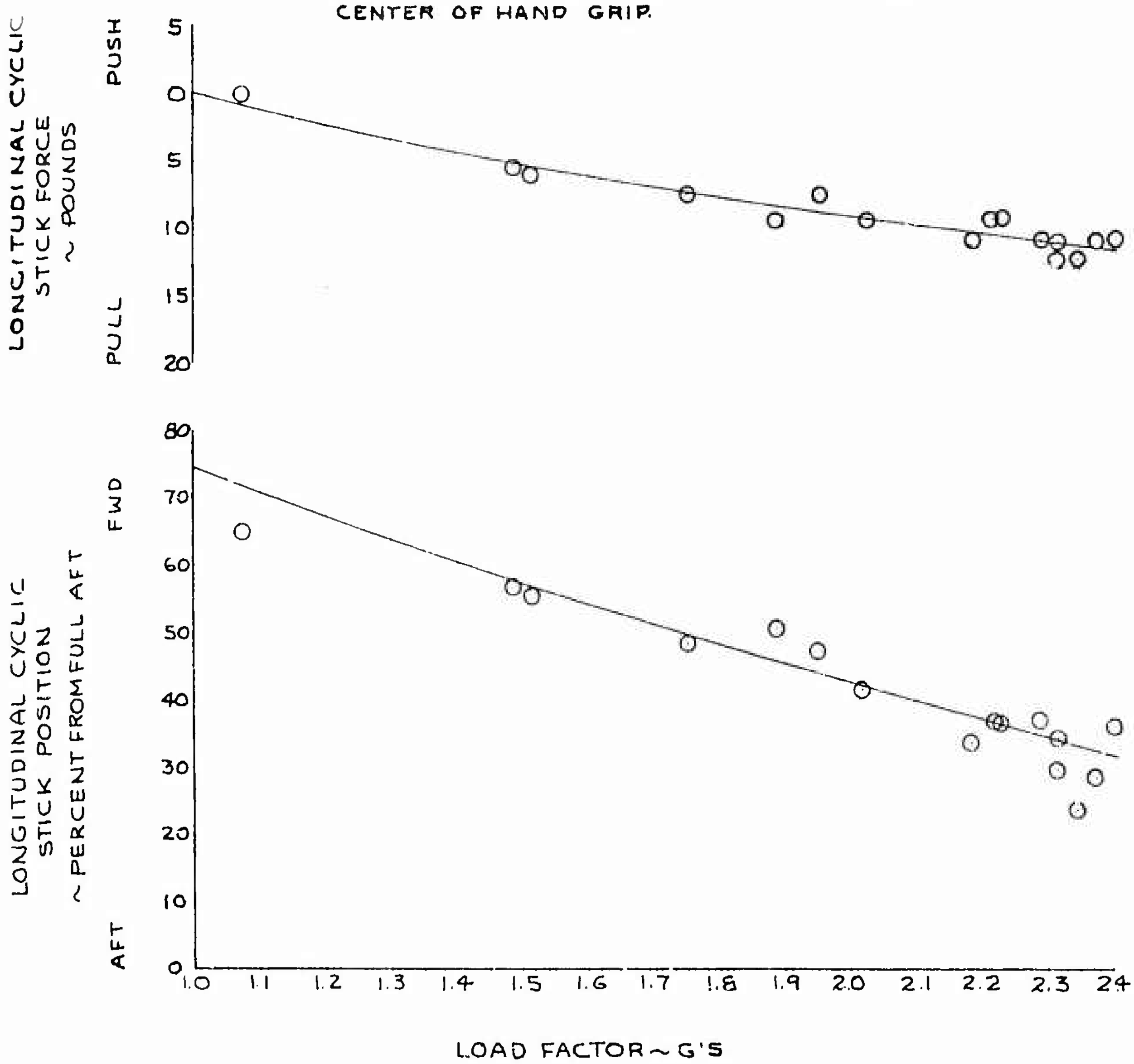
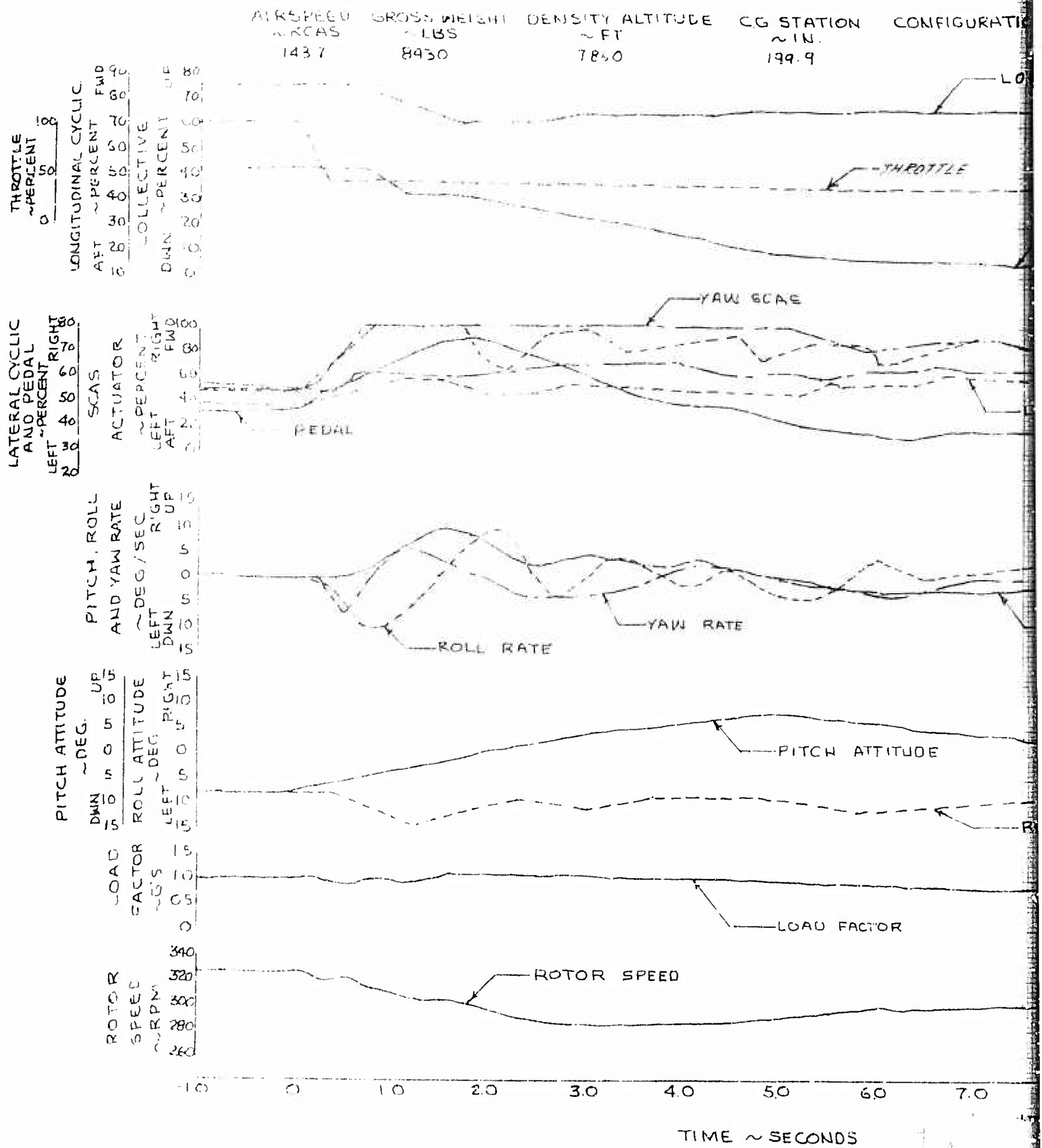
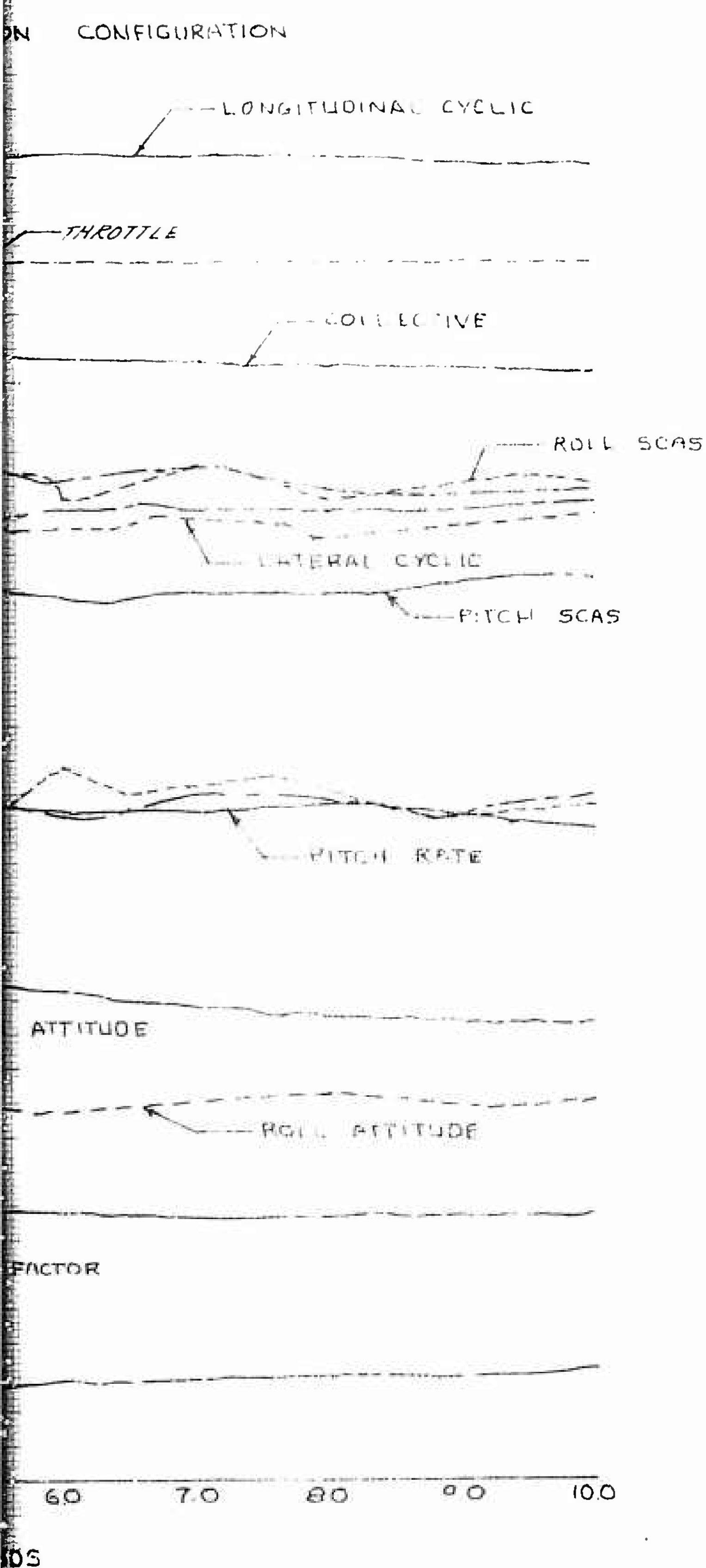


FIGURE No 30
THROTTLE CHOP
AH-1G USA S/N 615248



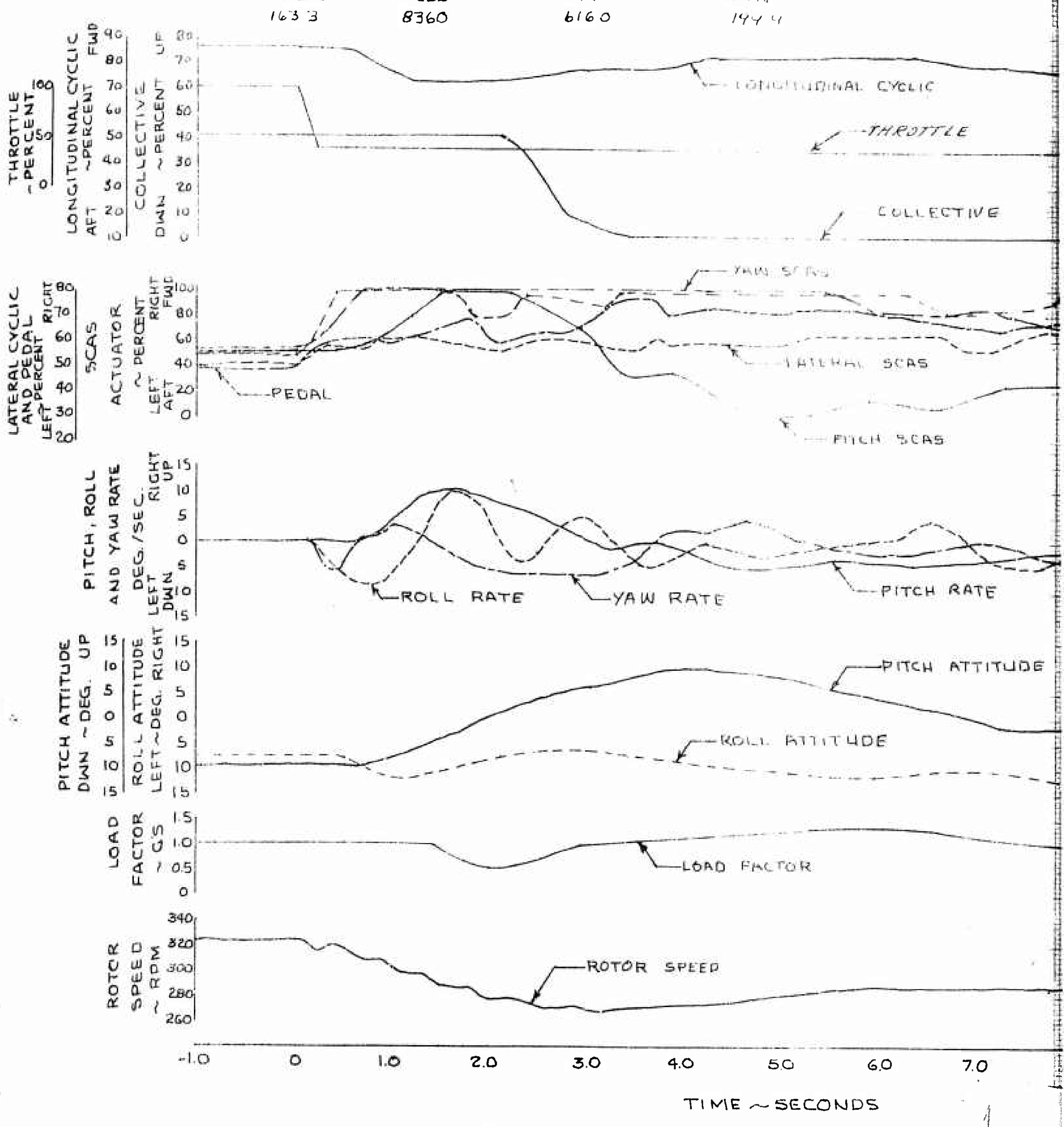


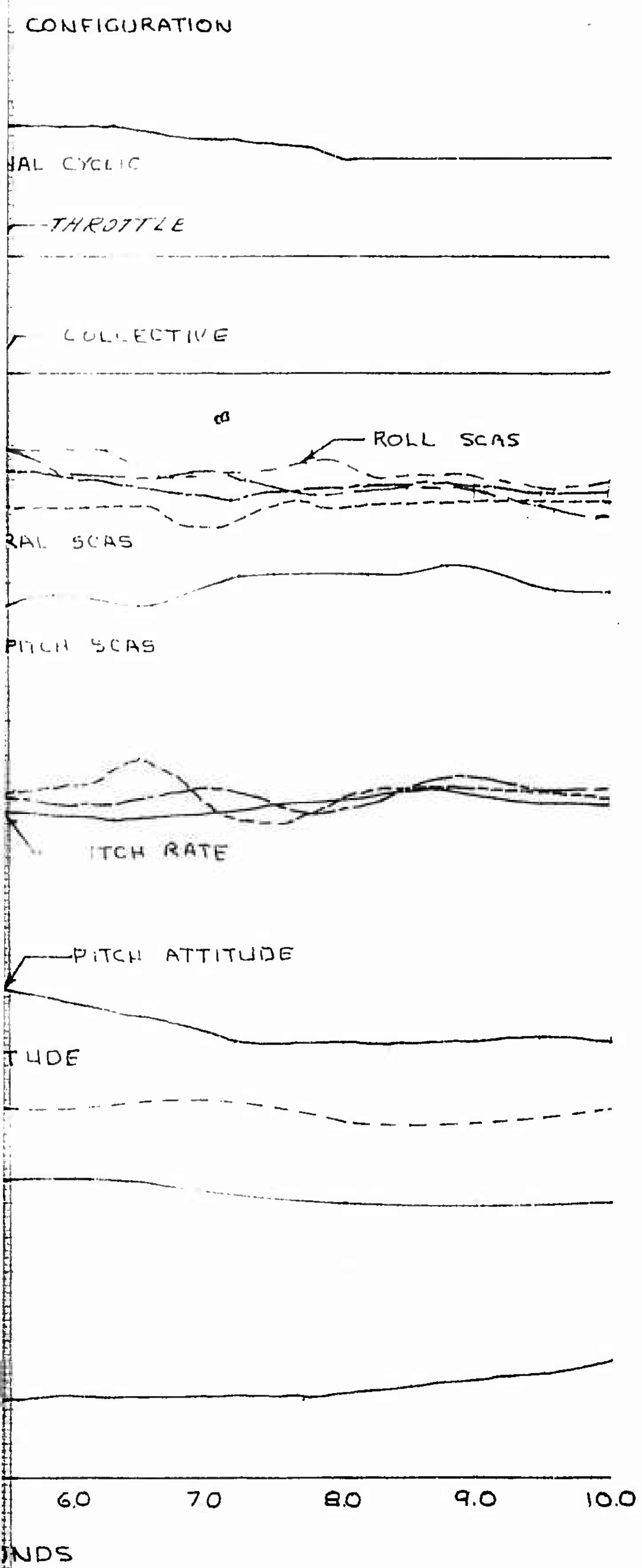
ON CONFIGURATION
LONGITUDINAL CYCLIC
THROTTLE
COLLECTIVE
ROLL SCAS
LATERAL CYCLIC
PITCH SCAS
PITCH RATE
ATTITUDE
ROLL ATTITUDE
FACTOR
6.0
7.0
8.0
9.0
10.0
DS

12

FIGURE No. 31
THROTTLE CHOP
AH-1G USA S/N 615248

AIRSPEED ~ KCAS	GROSS WEIGHT ~ LBS	DENSITY ALTITUDE ~ FT.	C.G. STATION ~ IN	CONFIGURATION
163.3	8360	6160	194.9	



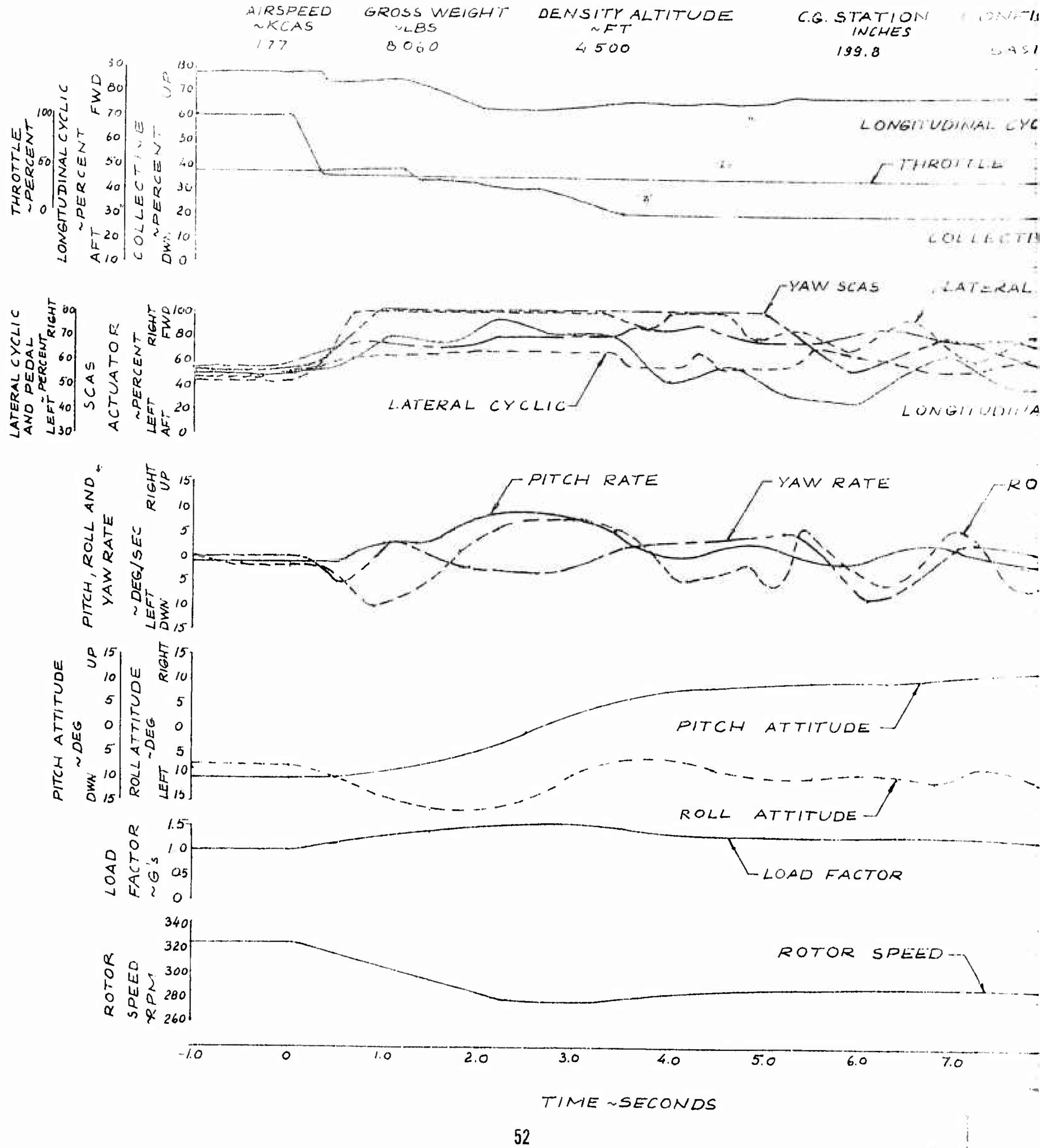

CONFIGURATION
NAL CYCLIC
THROTTLE
COLLECTIVE
ROLL SCAS
RAL SCAS
PITCH SCAS
ITCH RATE
PITCH ATTITUDE
TUDE
6.0
7.0
8.0
9.0
10.0
NDS

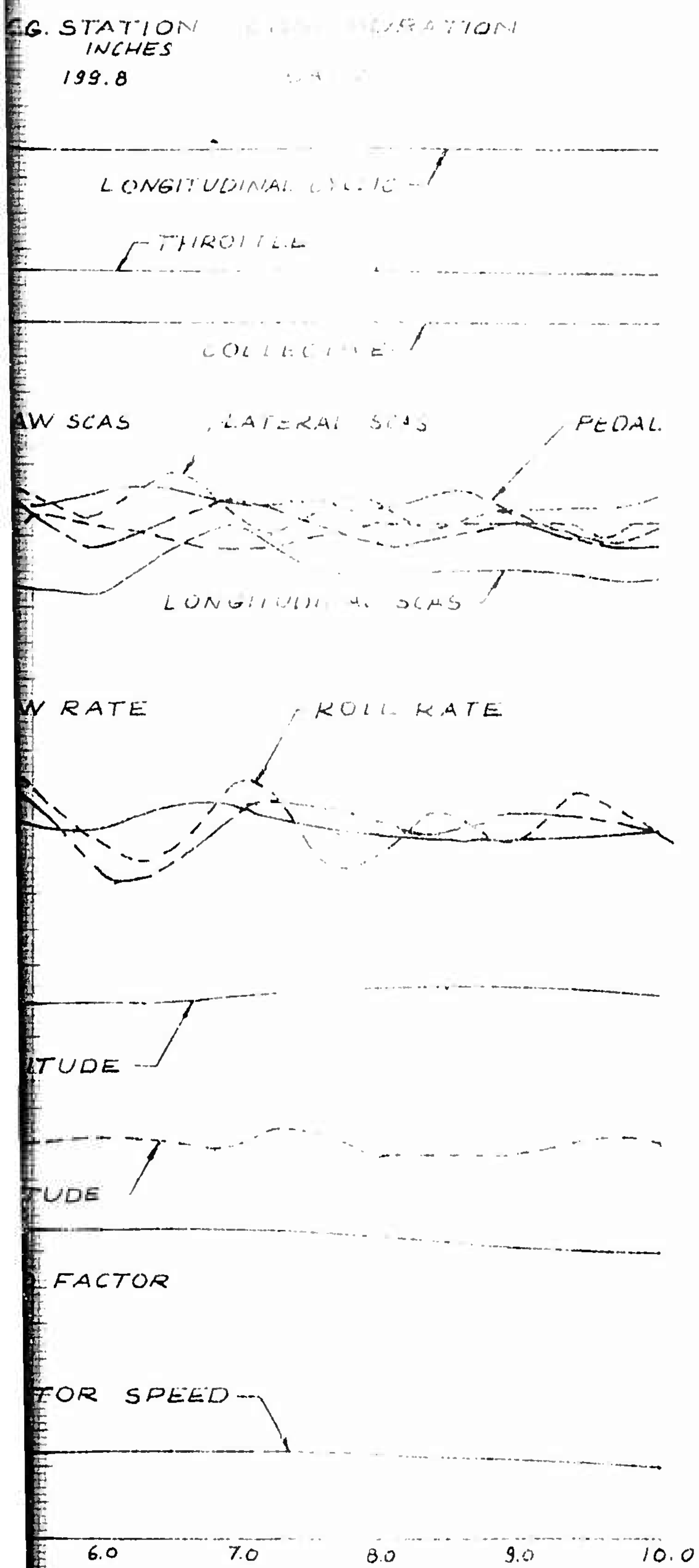
2

FIGURE NO 32

THROTTLE CHOP

AH-1G USA S/N 615248





G. STATION
INCHES
199.8
LONGITUDINAL
THROTTLE
AW SCAS
PEDAL
W RATE
ROLL RATE
TUDE
TUDE
FACTOR
TOR SPEED
6.0
7.0
8.0
9.0
10.0

FIGURE NO 33
LONGITUDINAL CYCLIC STICK FORCES
AH-1G USA S/N 615248

NOTES: 1. ROTOR STATIC.
2. FORCE TRIM ON.
3. FORCES MEASURED AT CENTER OF GRIP.
4. HYDRAULIC AND ELECTRICAL POWER PROVIDED BY GROUND POWER UNITS.
5. ADJUSTABLE FRICTION FULL OFF.

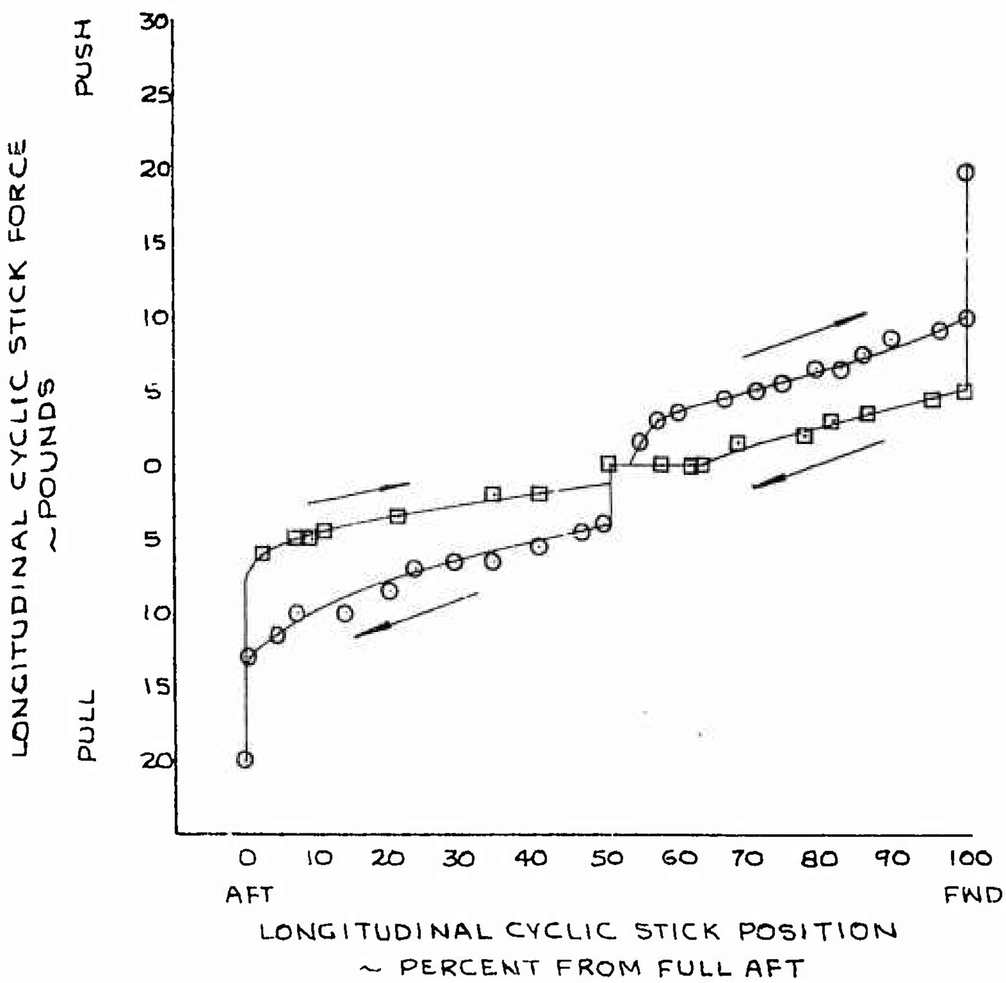


FIGURE NO. 34

LONGITUDINAL CYCLIC STICK FORCES

AH-1G USA S/N 615248

NOTES: 1. ROTOR STATIC.
2. FORCE TRIM OFF.
3. FORCES MEASURED AT CENTER OF GRIP.
4. HYDRAULIC AND ELECTRICAL POWER PROVIDED BY GROUND POWER UNITS.
5. ADJUSTABLE FRICTION SET AT CONTRACTOR'S RECOMMENDED VALUE.

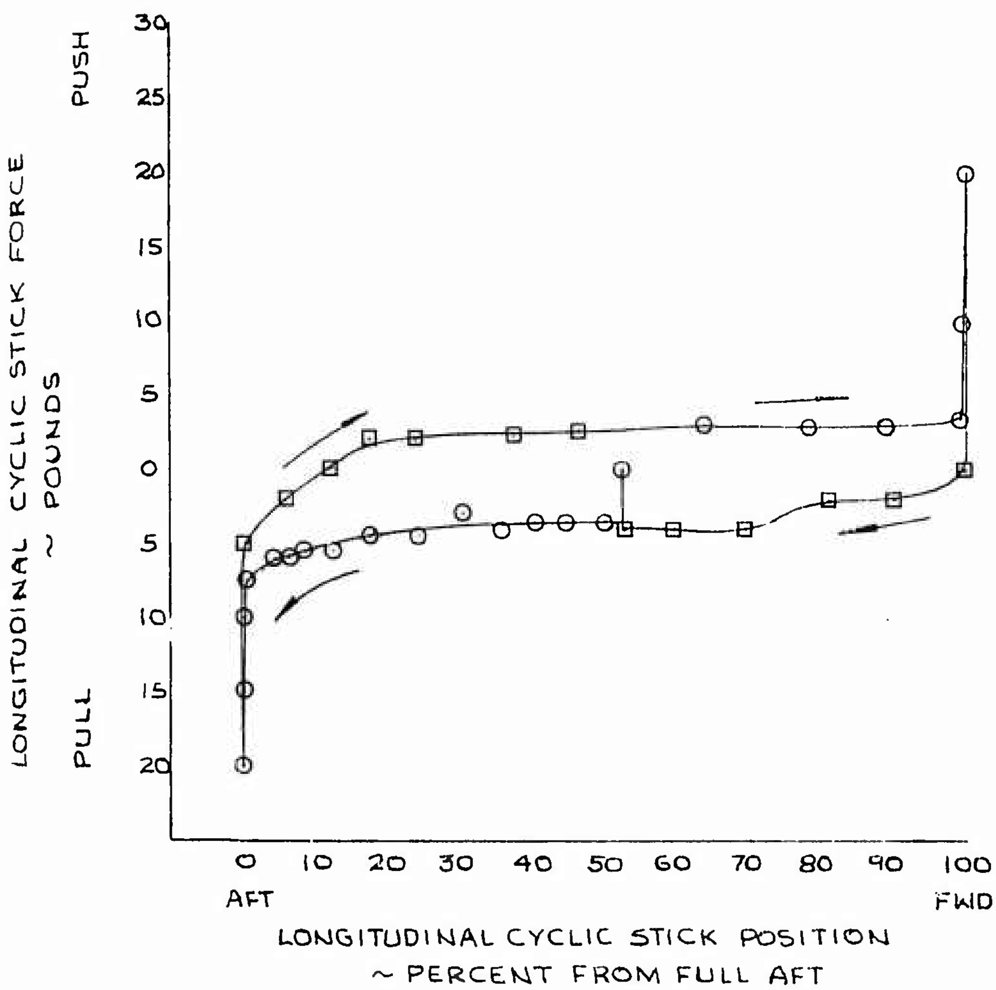


FIGURE No. 35

LATERAL CYCLIC STICK FORCES

AH-1G USA S/N 615248

NOTES: 1. ROTOR STATIC.
2. FORCE TRIM ON.
3. FORCES MEASURED AT CENTER OF GRIP
4. HYDRAULIC AND ELECTRICAL POWER. PROVIDED BY GROUND POWER UNITS
5. ADJUSTABLE FRICTION FULL OFF.

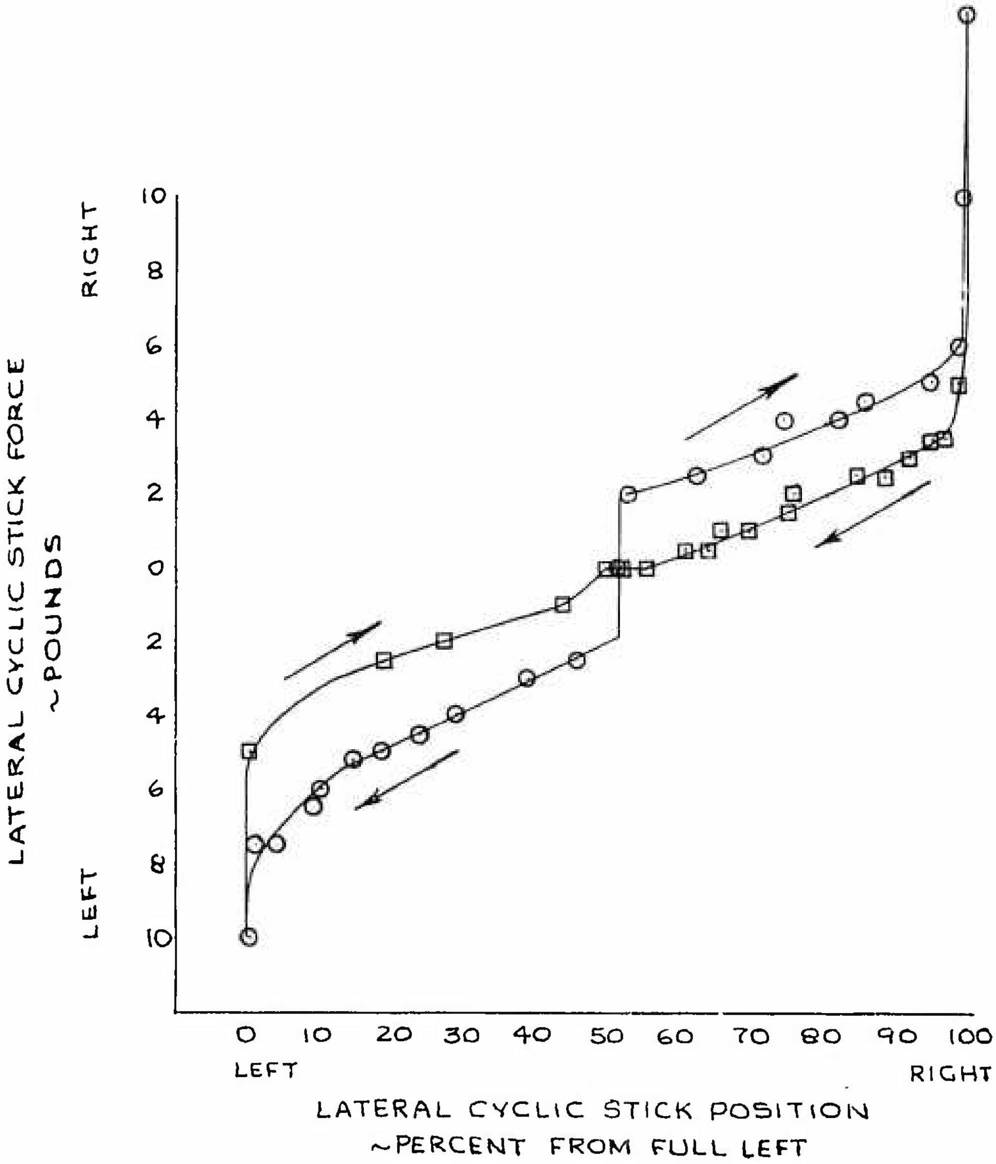


FIGURE No. 36

LATERAL CYCLIC STICK FORCES

AH-1G USA S/N 61 5248

NOTES: 1. ROTOR STATIC.
2. FORCE TRIM OFF.
3. FORCES MEASURED AT CENTER OF GRIP.
4. HYDRAULIC AND ELECTRICAL POWER PROVIDED BY GROUND POWER UNITS.
5. ADJUSTABLE FRICTION SET AT CONTRACTOR'S RECOMMENDED VALUE.

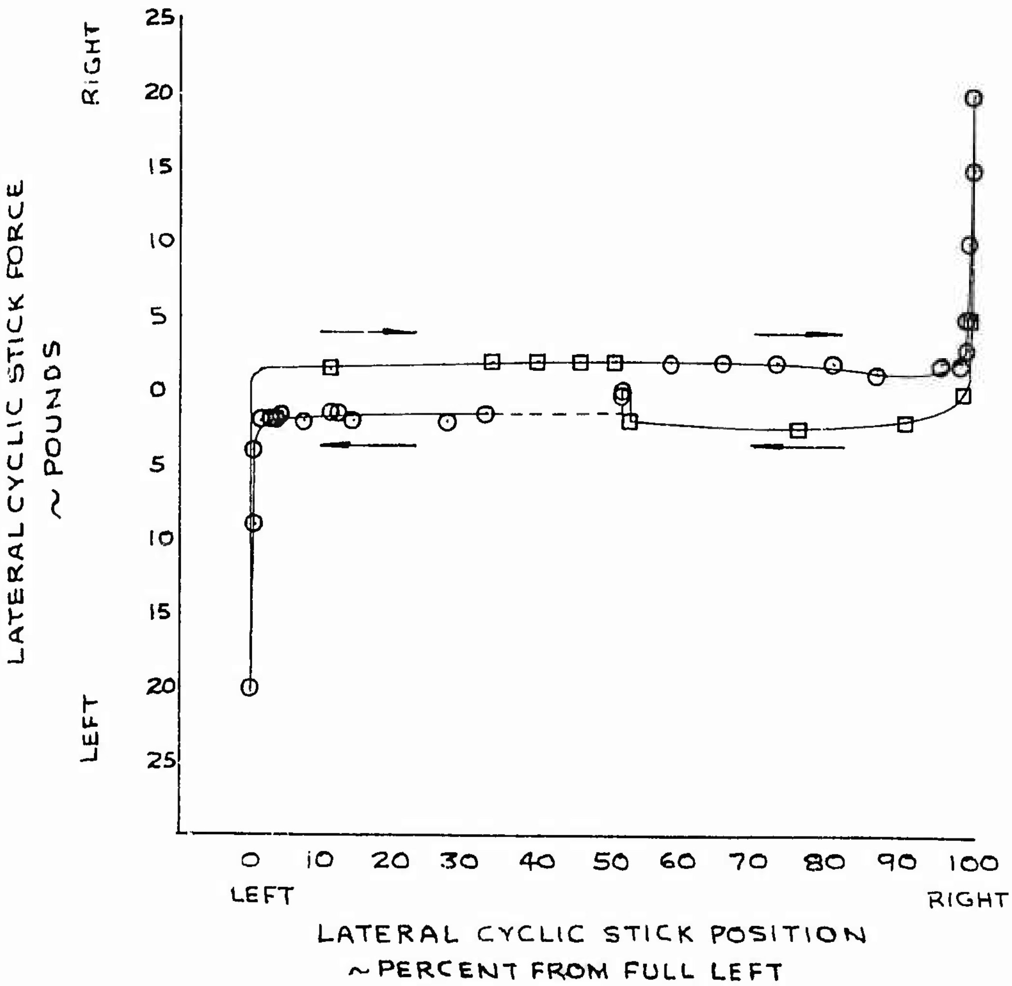


FIGURE NO. 37
VIBRATION CHARACTERISTICS
AH-1G USA S/N 615296

SYMBOL	GROSS WEIGHT ~POUNDS	DENSITY ALTITUDE ~ FEET	ROTOR SPEED ~ RPM	C.G. STATION ~ INCHES	CONFIGURATION
○	9290	3700	324	194.8	HOG
□	8200	3600	324	195.1	GUARANTEE

PILOT VERTICAL

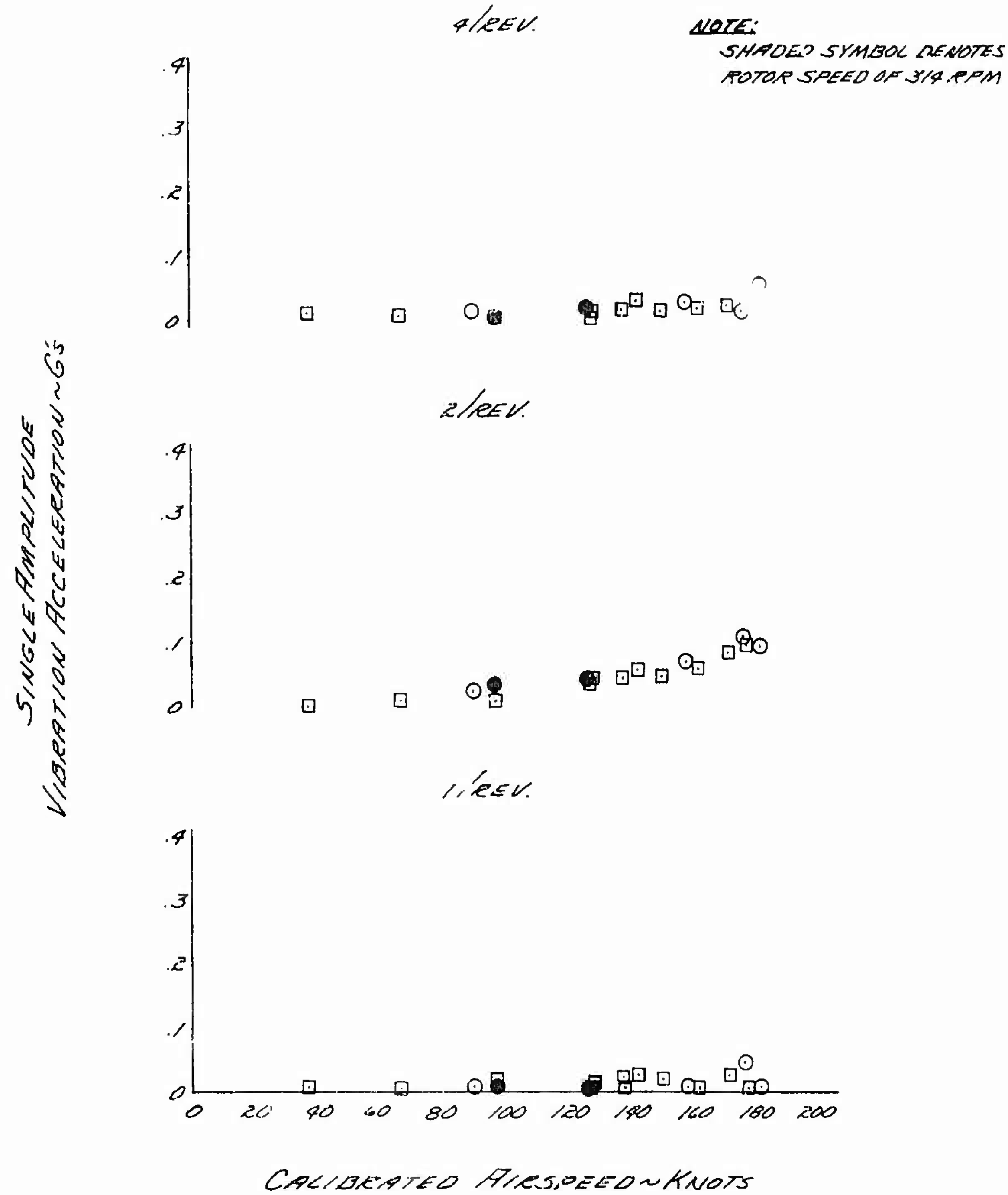


FIGURE NO. 38
VIBRATION CHARACTERISTICS
AH-1G USA S/N 615246

SYMBOL	GROSS WEIGHT ~ POUNDS	DENSITY ALTITUDE ~ FEET	ROTOR SPEED ~ RPM	C.G. STATION ~ INCHES	CONFIGURATION
○	9290	3700	324	194.8	HOG
□	8200	3600	324	195.1	GUARANTEE

PILOT VERTICAL

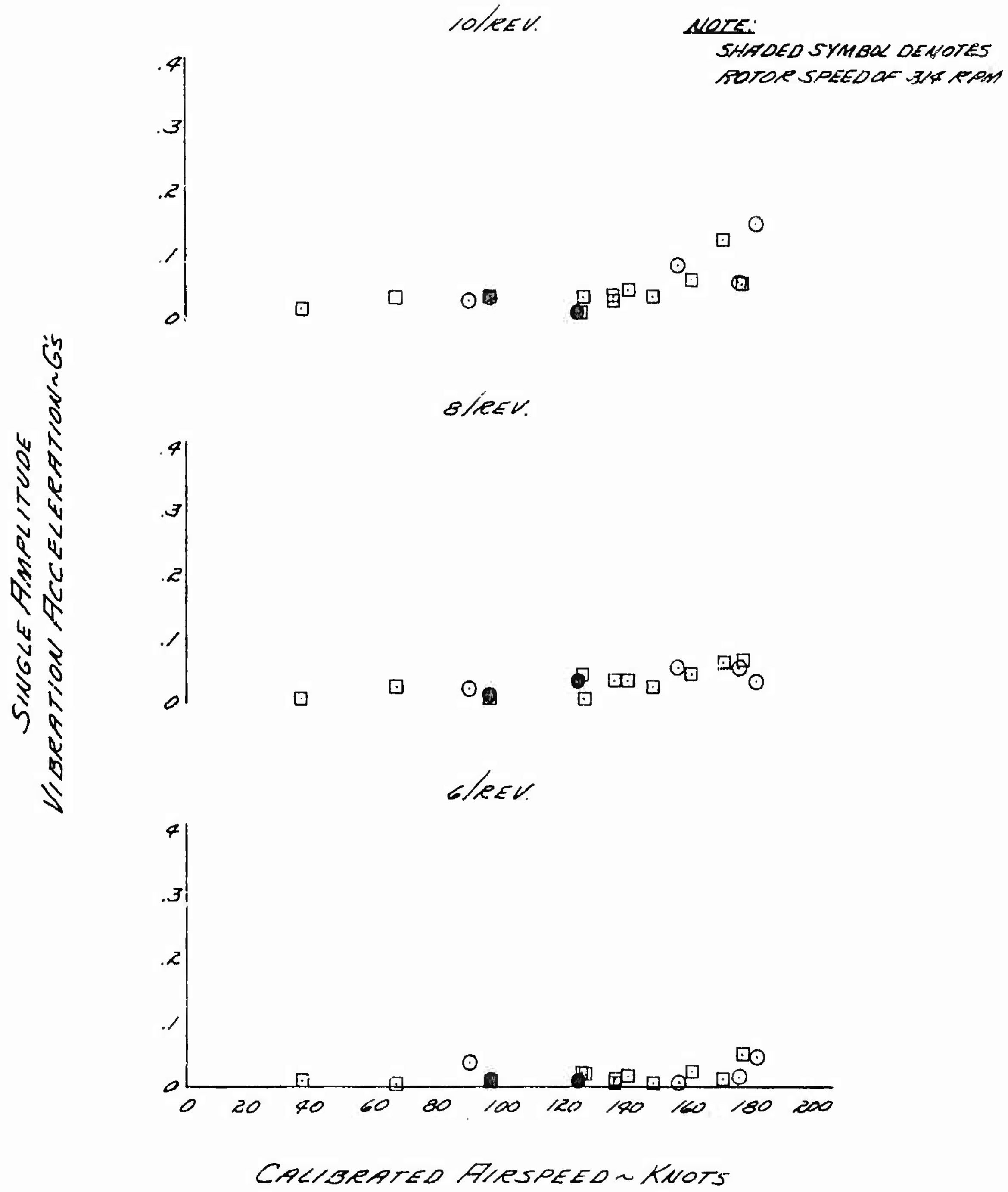


FIGURE NO. 39
VIBRATION CHARACTERISTICS
AH-1G USA S/N 615296

SYMBOL	GROSS WEIGHT ~POUNDS	DENSITY ALTITUDE ~FEET	ROTOR SPEED ~RPM	C.G. STATION ~ INCHES	CONFIGURATION
○	9290	3700	329	194.8	HOG
□	8200	3600	324	195.1	GUARANTEE

GUNNER VERTICAL

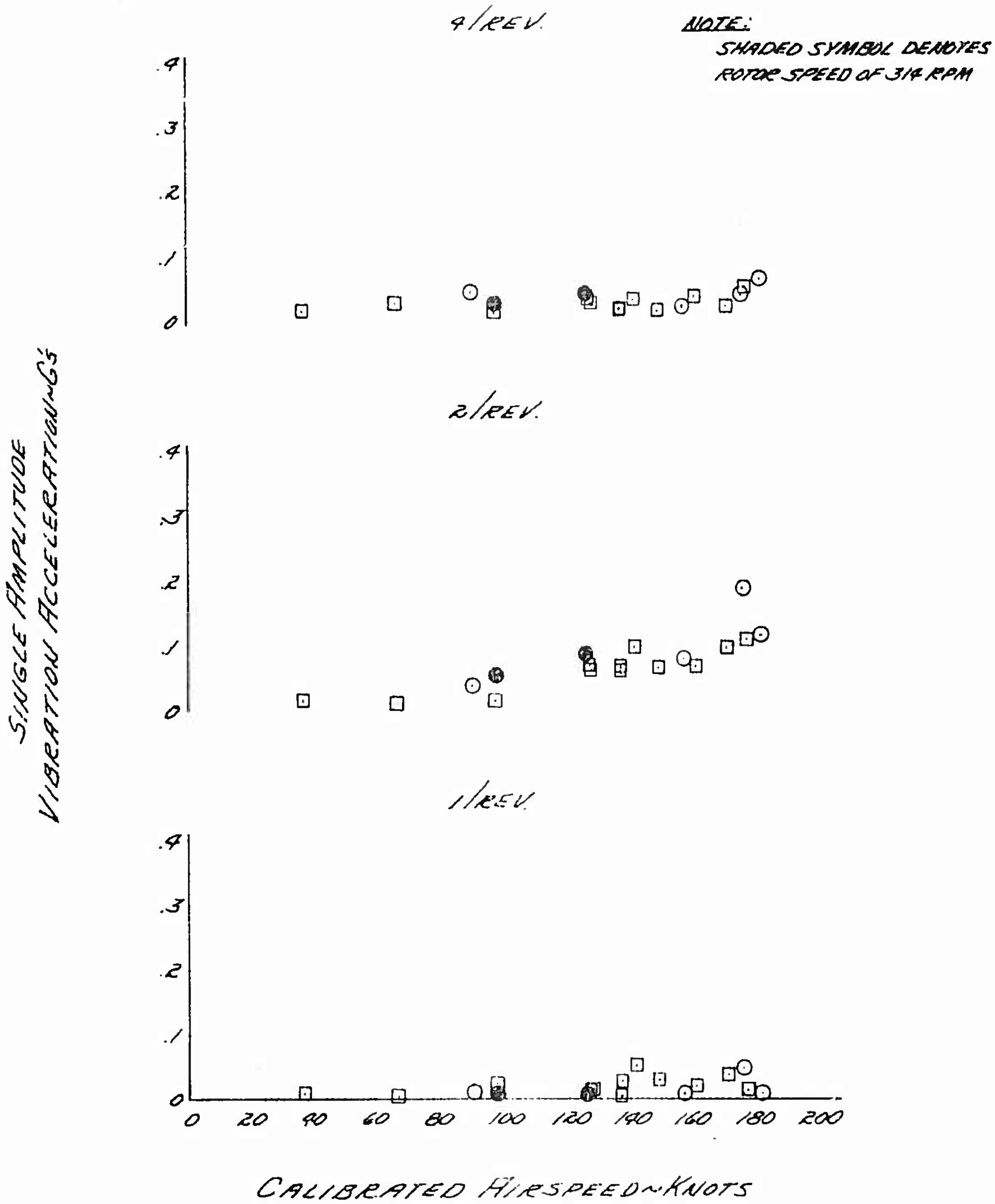


FIGURE No. 40
VIBRATION CHARACTERISTICS
AH-1G USA S/N 615246

SYMBOL	GROSS WEIGHT ~POUNDS	DENSITY ALTITUDE ~FEET	ROTOR SPEED ~RPM	C.G. STATION ~INCHES	CONFIGURATION
○	9290	3700	324	194.8	HOG
□	8200	3600	324	195.1	GUARANTEE

GUNNER VERTICAL

NOTE:
SHADED SYMBOL DENOTES ROTOR SPEED OF 314 RPM

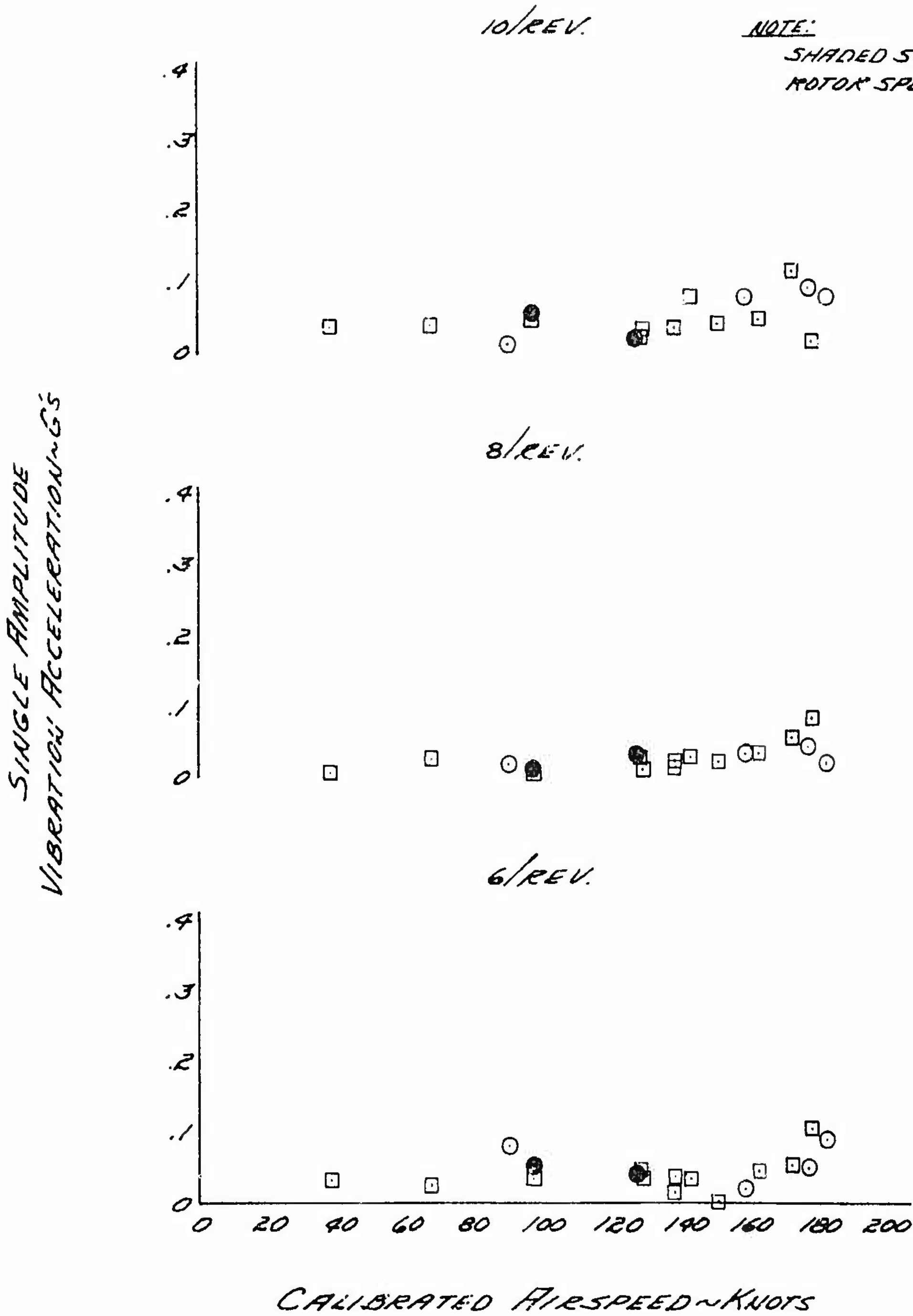


FIGURE No. 41
VIBRATION CHARACTERISTICS
AH-1G USA S/N 615246

SYMBOL	GROSS WEIGHT ~POUNDS	DENSITY ALTITUDE ~FEET	ROTOR SPEED ~RPM	C.G. STATION ~INCHES	CONFIGURATION
○	9250	3700	324	194.8	HOG
□	8200	3600	324	195.1	GUARANTEE

PILOT LATERAL

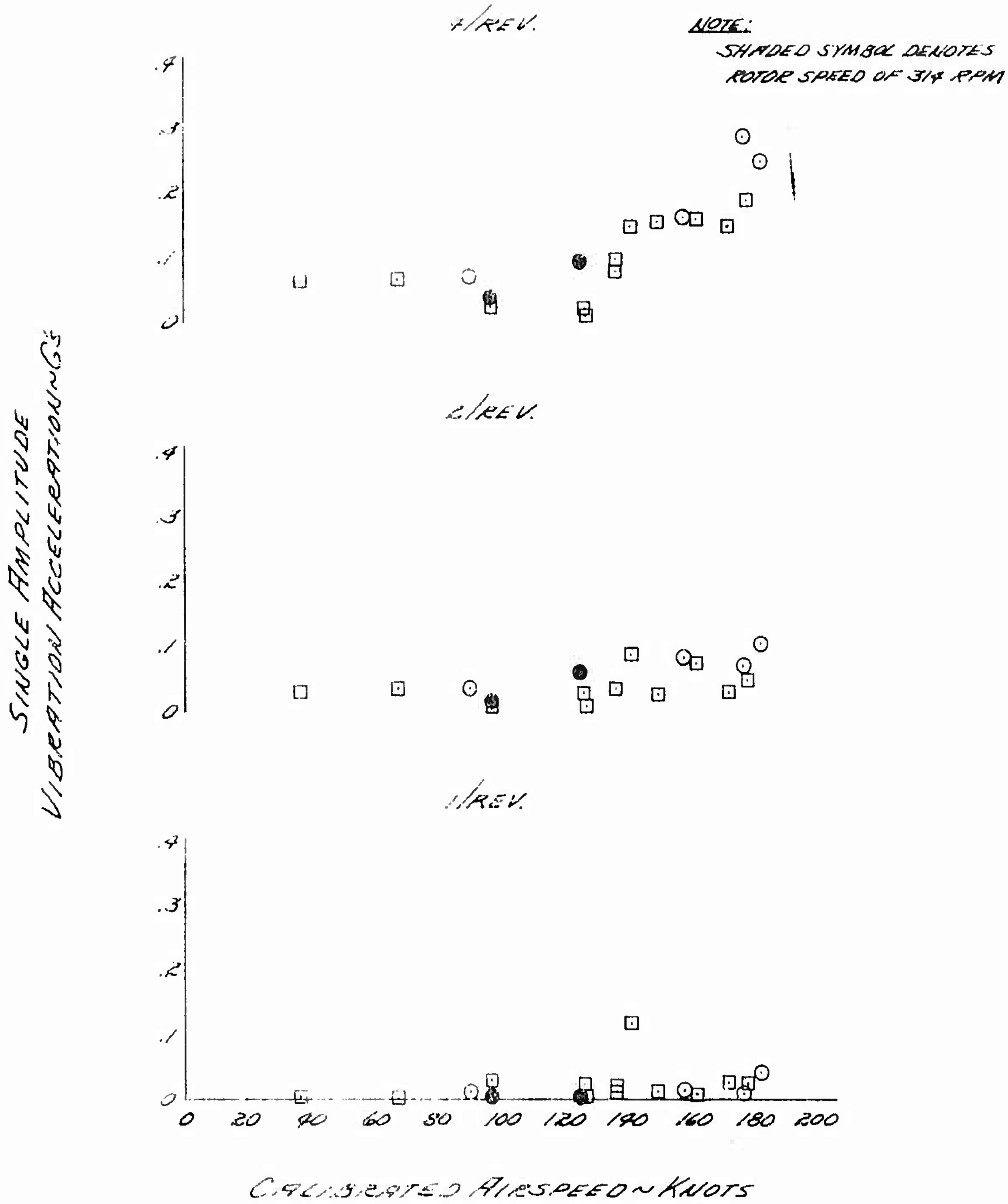


FIGURE NO. 42
VIBRATION CHARACTERISTICS
AH-1G USA S/N 615246

SYMBOL	GROSS WEIGHT ~POUNDS	DENSITY ALTITUDE ~FEET	ROTOR SPEED ~RPM	C.G. STATION ~INCHES	CONFIGURATION
○	9290	3700	324	194.8	HOG
□	8200	3600	324	195.1	GUARANTEE

PILOT LATERAL

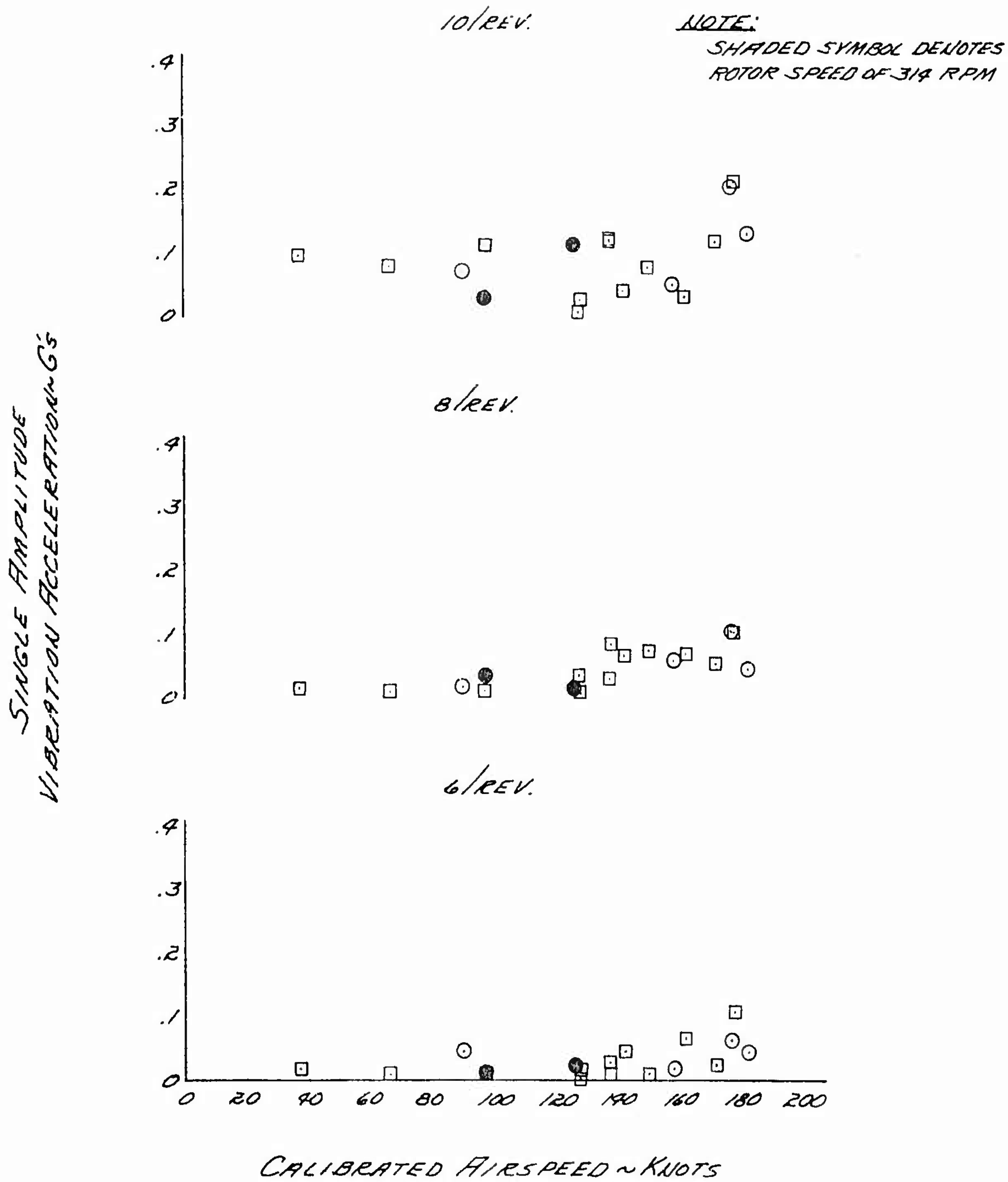


FIGURE NO. 43
VIBRATION CHARACTERISTICS
AH-1G USA S/N 615246

SYMBOL	GROSS WEIGHT ~POUNDS	DENSITY ALTITUDE ~FEET	ROTOR SPEED ~RPM	C.G. STATION ~INCHES	CONFIGURATION
○	9290	3700	324	194.8	H.O.G.
□	8200	3600	324	195.1	GUARANTEE

GUNNER LATERAL

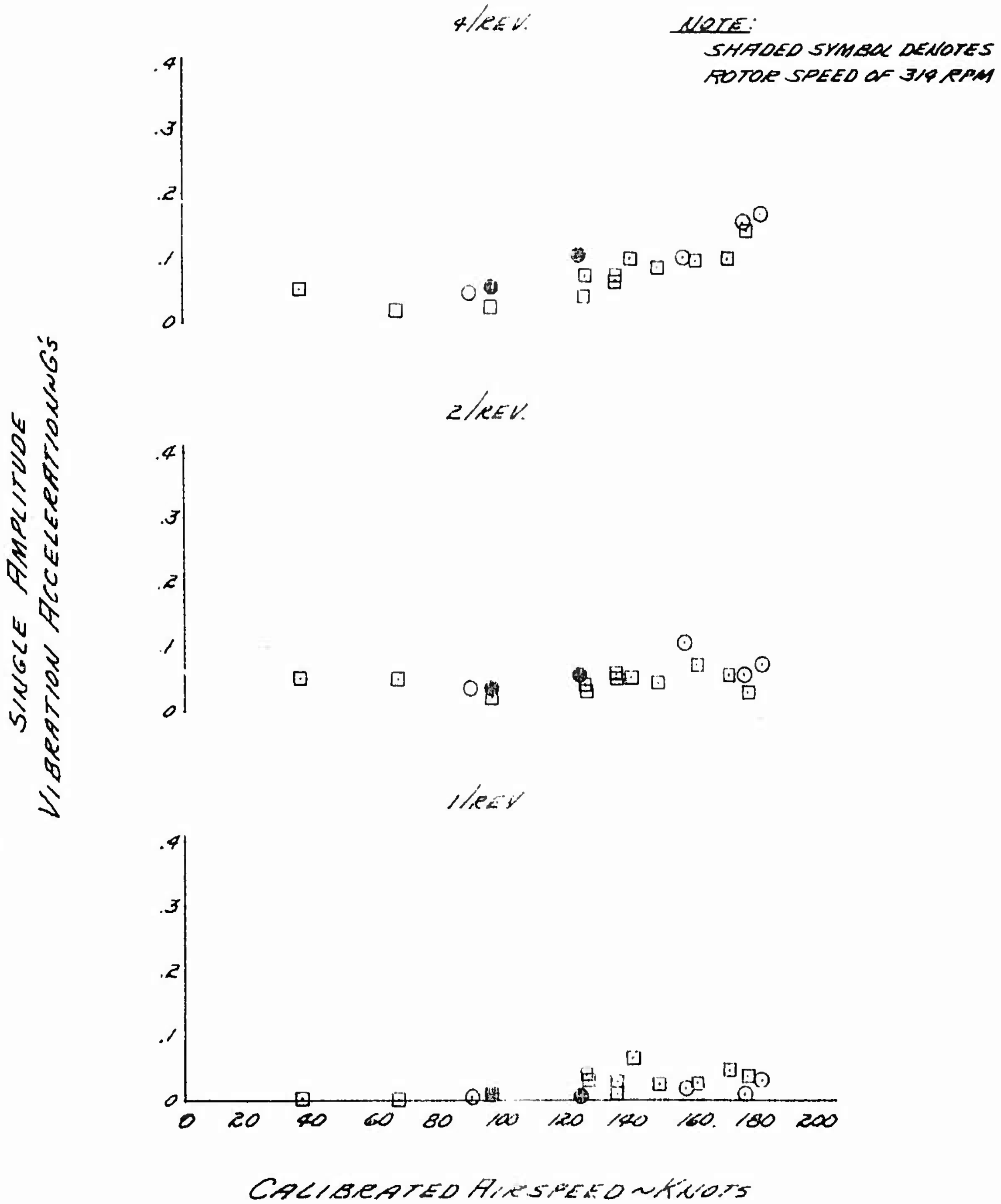


FIGURE NO. 44
VIBRATION CHARACTERISTICS
AH-1G USA S/N 615246

SYMBOL	GROSS WEIGHT ~POUNDS	DENSITY ALTITUDE ~FEET	ROTOR SPEED ~RPM	C.G. STATION ~INCHES	CONFIGURATION
○	9290	3700	324	194.8	HOG
□	8200	3600	324	195.1	GUARANTEE

GUNNER LATERAL

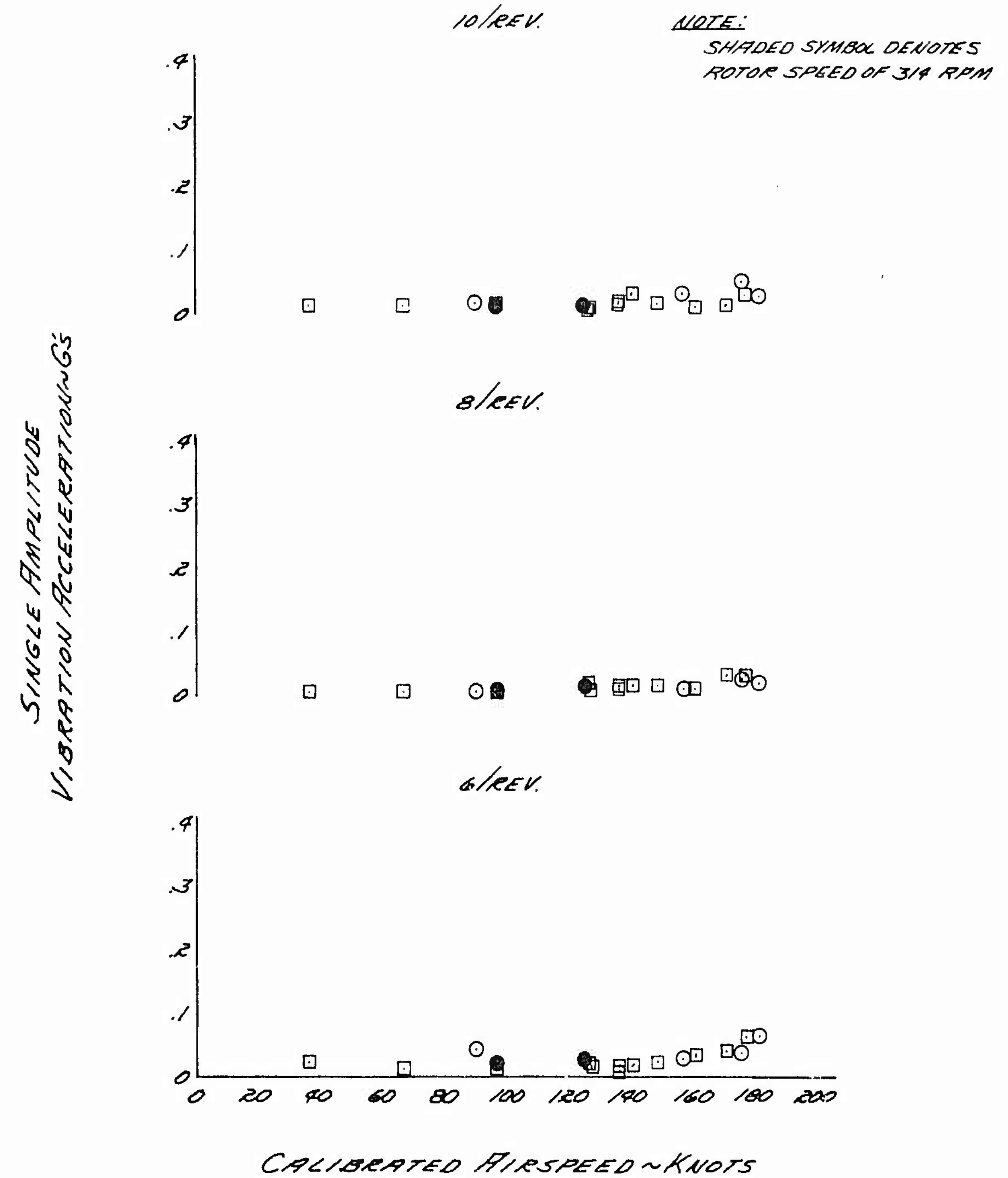


FIGURE NO 45
VIBRATION CHARACTERISTICS
AH-1G USA S/N 615246

SYMBOL	GROSS WEIGHT ~POUNDS	DENSITY ALTITUDE ~FEET	ROTOR SPEED ~RPM	C.G. STATION ~INCHES	CONFIGURATION
○	9290	3700	324	194.8	HOG
□	8200	3600	324	195.1	GUARANTEE

PILOT LONGITUDINAL

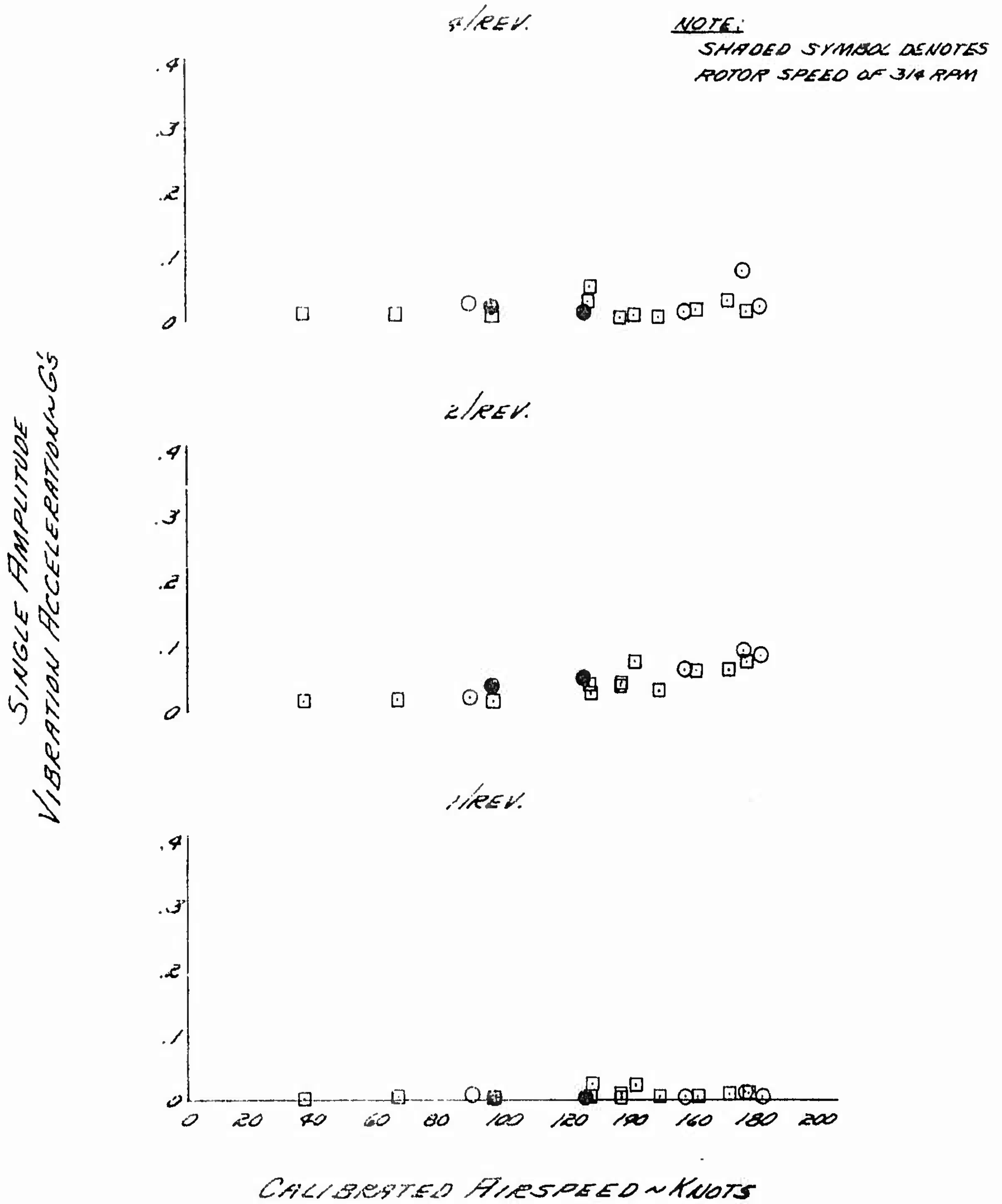


FIGURE NO. 46
VIBRATION CHARACTERISTICS
AH-1G USA S/N 615246

SYMBOL	GROSS WEIGHT ~POUNDS	DENSITY ALTITUDE ~ FEET	ROTOR SPEED ~RPM	C.G. STATION ~INCHES	CONFIGURATION
○	9290	3700	324	194.8	HOG
□	8200	3600	324	195.1	GUARANTEE

PILOT LONGITUDINAL

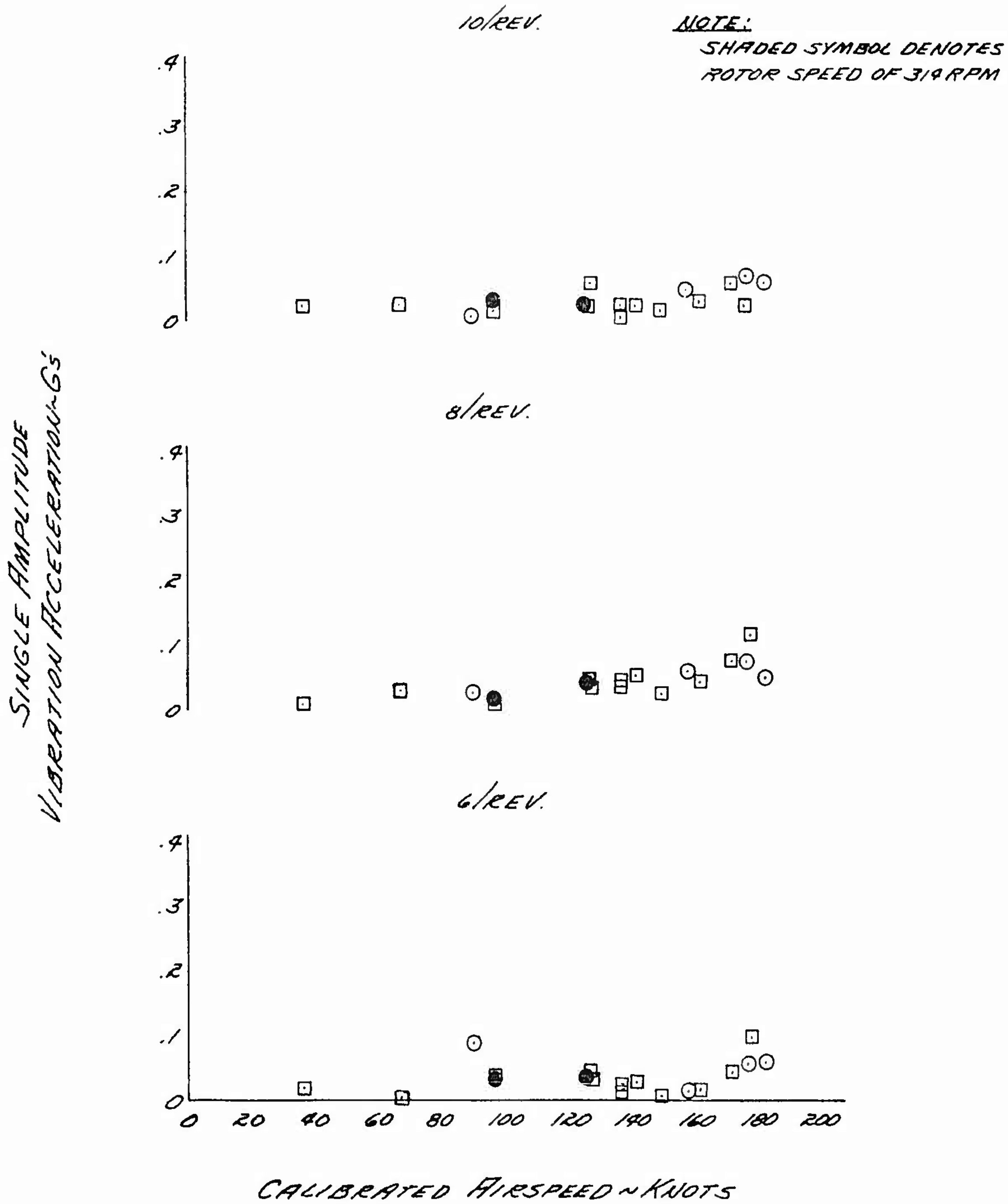


FIGURE NO. 47

VIBRATION CHARACTERISTICS

AH-1G USA S/N 615246

SYMBOL	GROSS WEIGHT ~POUNDS	DENSITY ALTITUDE ~FEET	ROTOR SPEED ~RPM	C.G. STATION ~INCHES	CONFIGURATION
○	9290	3700	324	194.8	HOG
□	8200	3600	324	195.1	GUARANTEE

GUNNER LONGITUDINAL

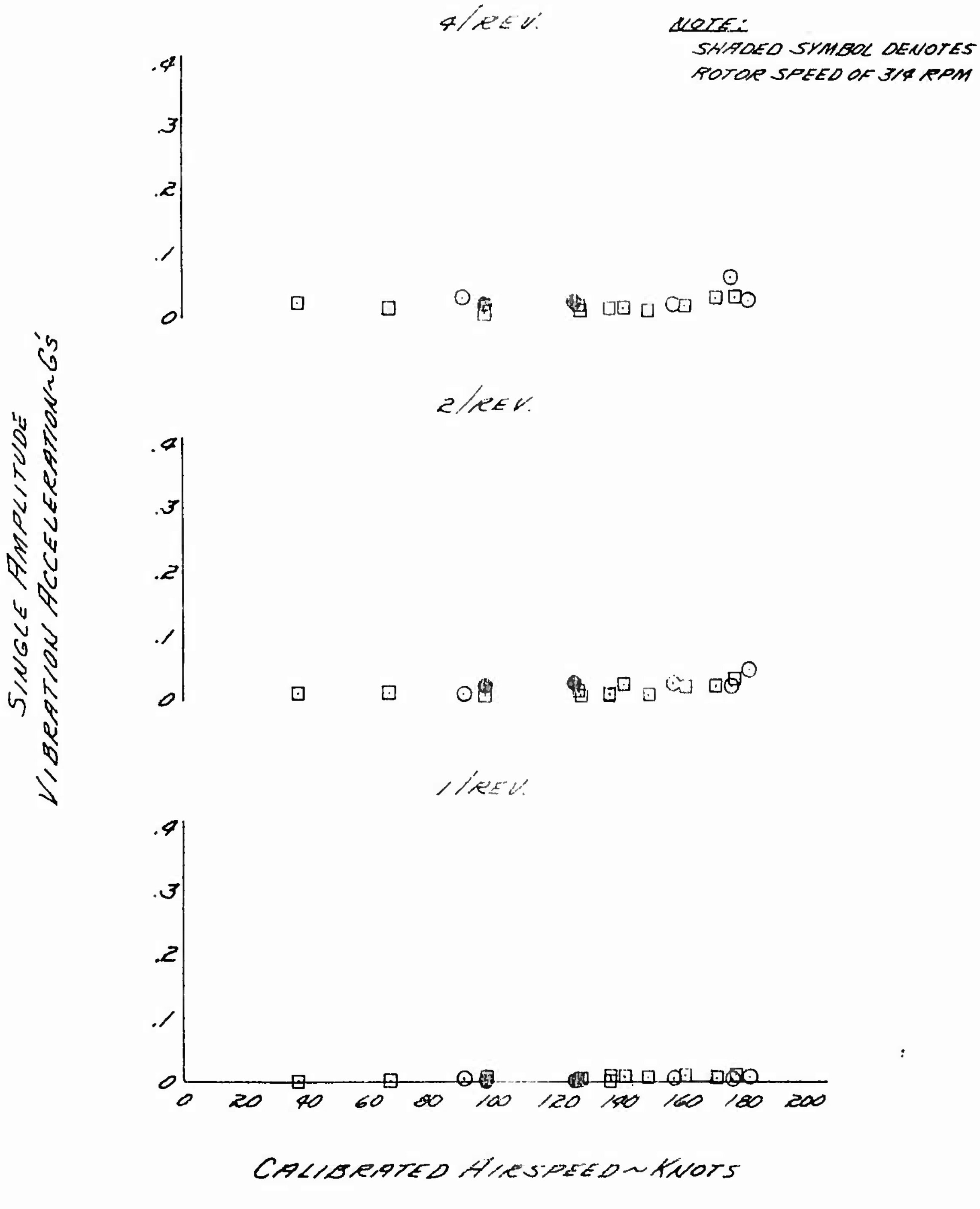


FIGURE NO. 48

VIBRATION CHARACTERISTICS

AH-1G USA S/N 615296

SYMBOL	GROSS WEIGHT ~POUNDS	DENSITY ALTITUDE ~ FEET	ROTOR SPEED ~RPM	C.G. STATION ~INCHES	CONFIGURATION
○	9290	3700	324	194.8	HOG
□	8200	3600	324	195.1	GUARANTEE

GUNNER LONGITUDINAL

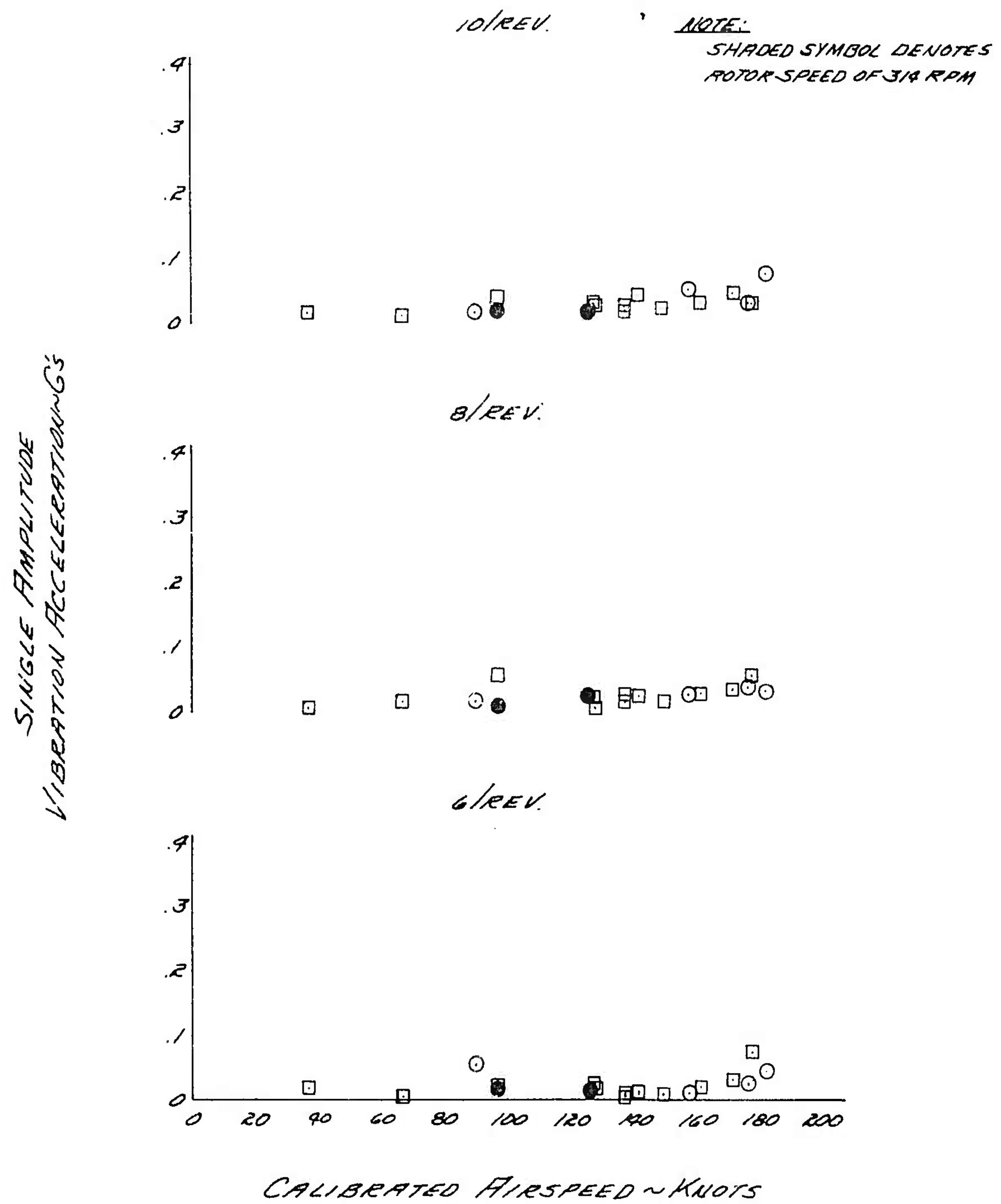


FIGURE NO. 49
VIBRATION CHARACTERISTICS
AH-1G USA S/N 615248

SYMBOL	GROSS WEIGHT ~ POUNDS	DENSITY ALTITUDE ~ FEET	ROTOR SPEED ~ RPM	C.G. STATION ~ INCHES	CONFIGURATION
○	7350	3570	324	199.2	HOG
□	8350	2860	324	199.9	GUARANTEE

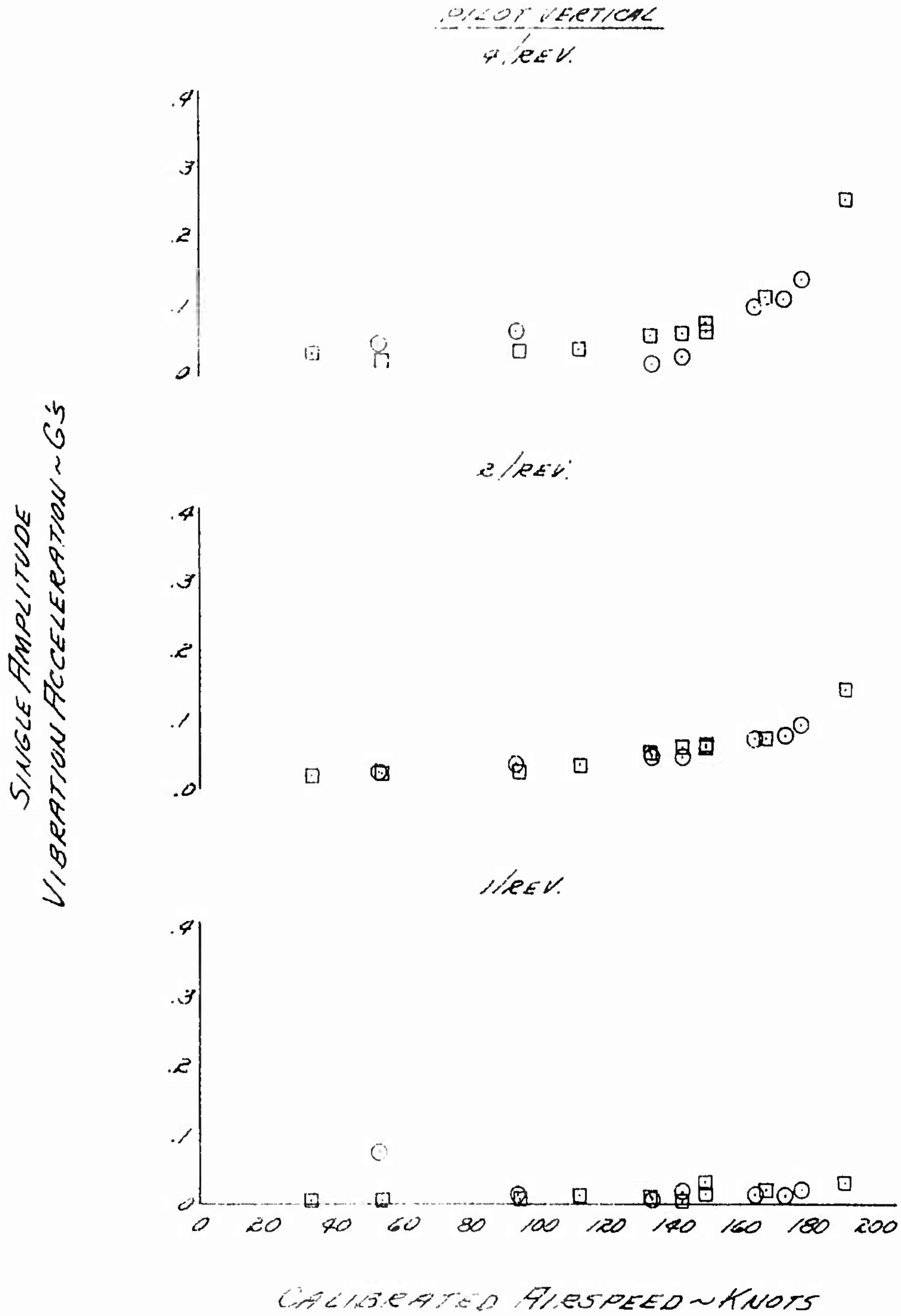


FIGURE NO. 50
VIBRATION CHARACTERISTICS
AH-1G USA S/N 615248

SYMBOL	GROSS WEIGHT ~ POUNDS	DENSITY ALTITUDE ~ FEET	ROTOR SPEED ~ RPM	C.G. STATION ~ INCHES	CONFIGURATION
○	7350	3970	324	199.2	HOG
□	8350	2860	324	199.9	GUARANTEE

PILOT VERTICAL

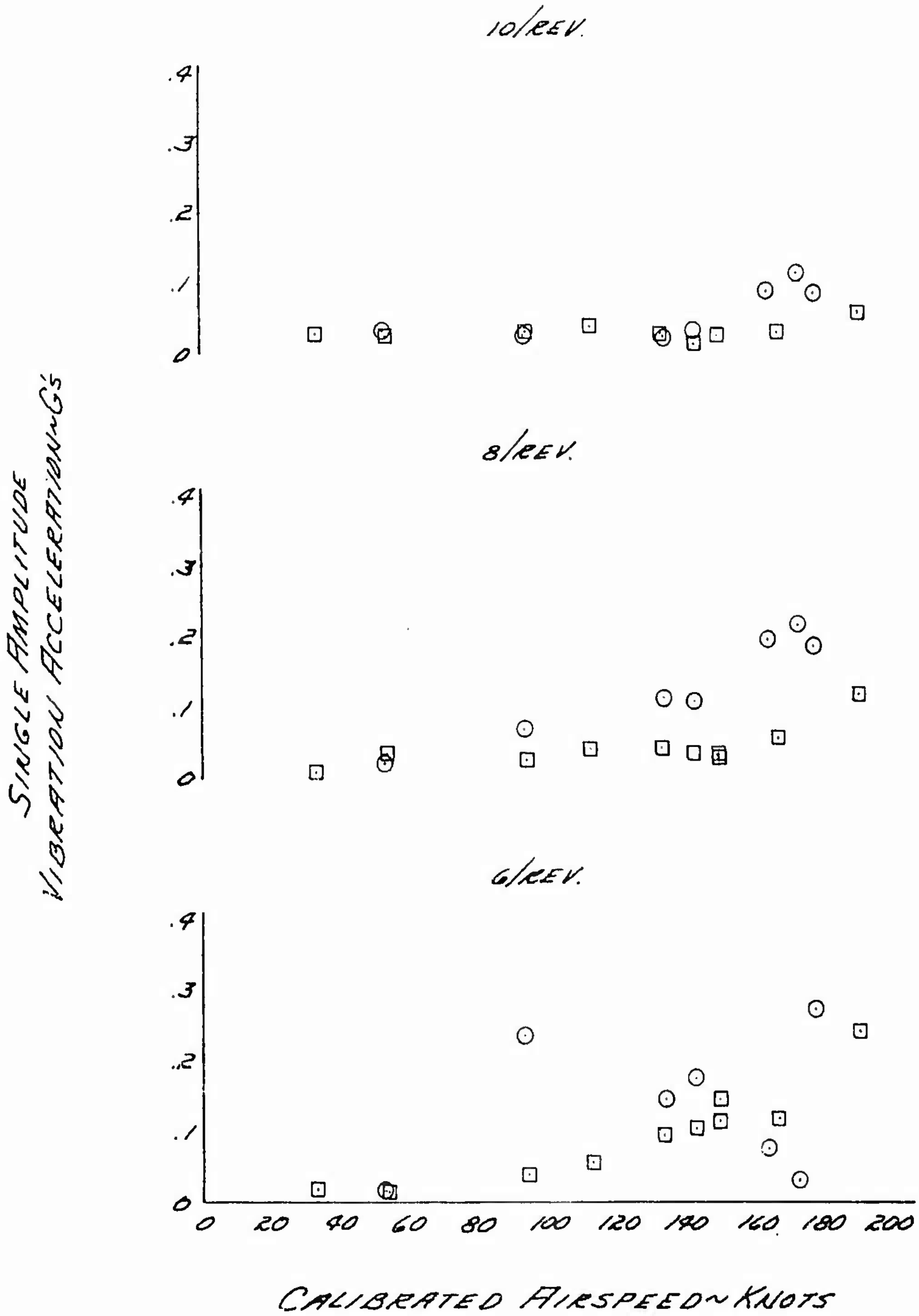


FIGURE NO. 51
VIBRATION CHARACTERISTICS
AH-1G USA S/N 615248

SYMBOL	GROSS WEIGHT ~POUNDS	DENSITY ALTITUDE ~FEET	ROTOR SPEED ~RPM	C.G. STATION ~INCHES	CONFIGURATION
○	7350	3970	324	199.2	HOG
□	8350	2860	324	199.	GUARANTEE

GUNNER VERTICAL

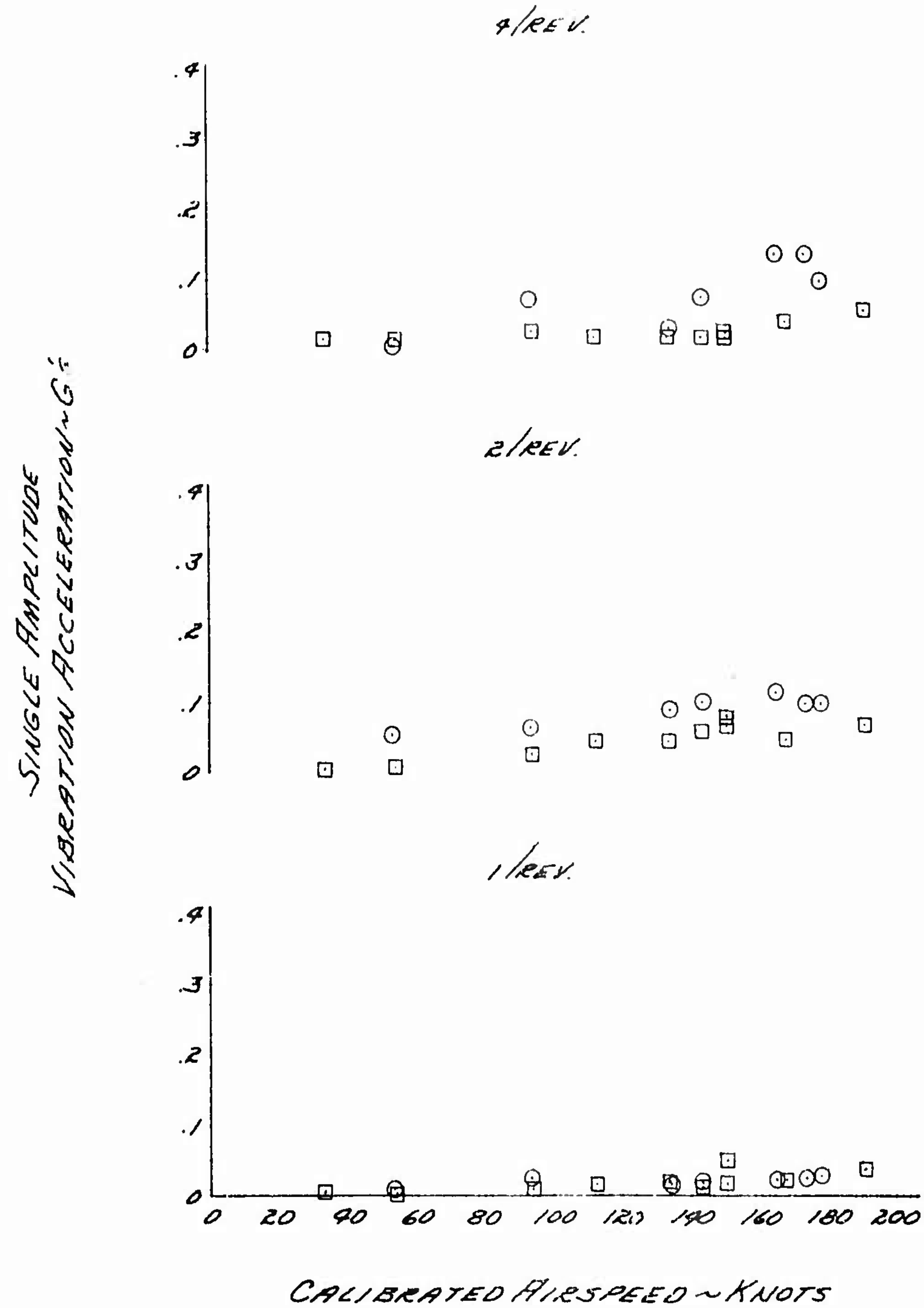


FIGURE No. 52
VIBRATION CHARACTERISTICS
AH-1G USA S/N 615248

SYMBOL	GROSS WEIGHT ~POUNDS	DENSITY ALTITUDE ~FEET	ROTOR SPEED ~RPM	C.G. STATION ~INCHES	CONFIGURATION
○	7350	3970	324	199.2	HOG
□	8350	2860	324	199.9	GUARANTEE

GUNNER VERTICAL

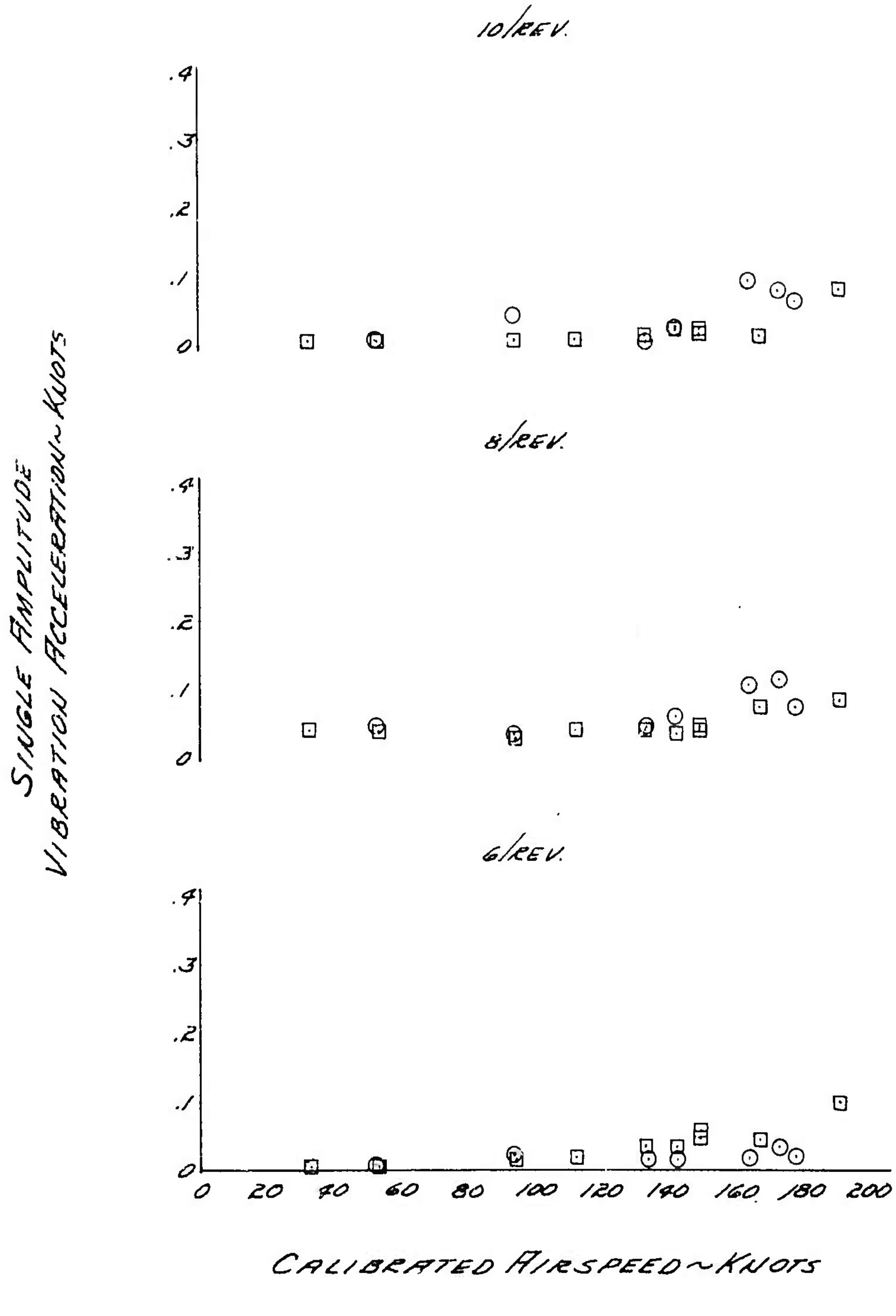


FIGURE NO. 53
VIBRATION CHARACTERISTICS
AH-1G USA S/N 615248

SYMBOL	GROSS WEIGHT ~POUNDS	DENSITY ALTITUDE ~FEET	ROTOR SPEED ~RPM	C.G. STATION ~INCHES	CONFIGURATION
○	7350	3970	324	199.2	HOG
□	8350	2860	324	199.9	GUARANTEE

PILOT LATERAL

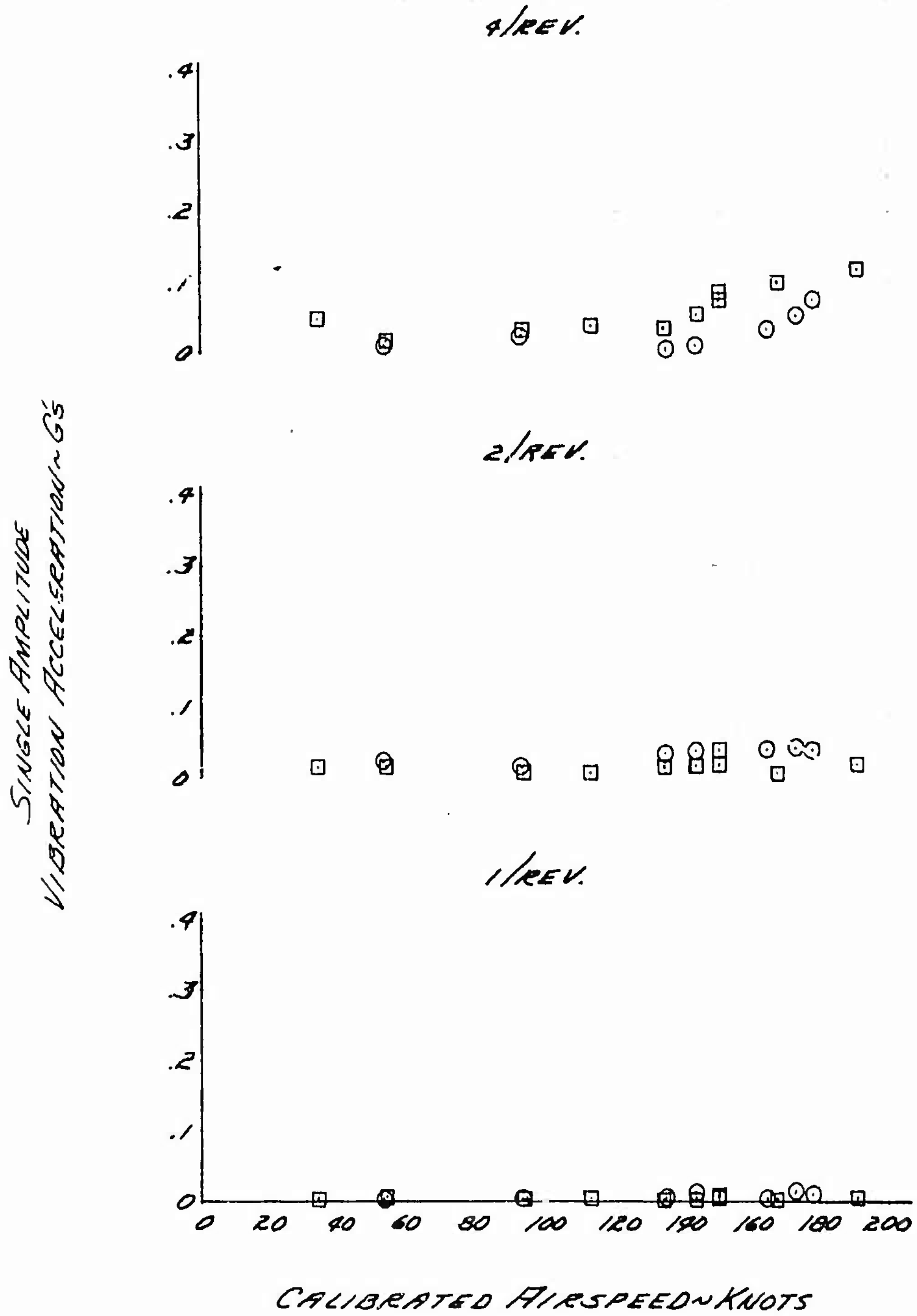


FIGURE No. 54
VIBRATION CHARACTERISTICS
AH-1G USA S/N 615248

SYMBOL	GROSS WEIGHT ~POUNDS	DENSITY ALTITUDE ~FEET	ROTOR SPEED ~RPM	C.G. STATION ~INCHES	CONFIGURATION
○	7350	3970	324	199.2	HOG
□	8350	2860	324	199.9	GUARANTEE

PILOT LATERAL

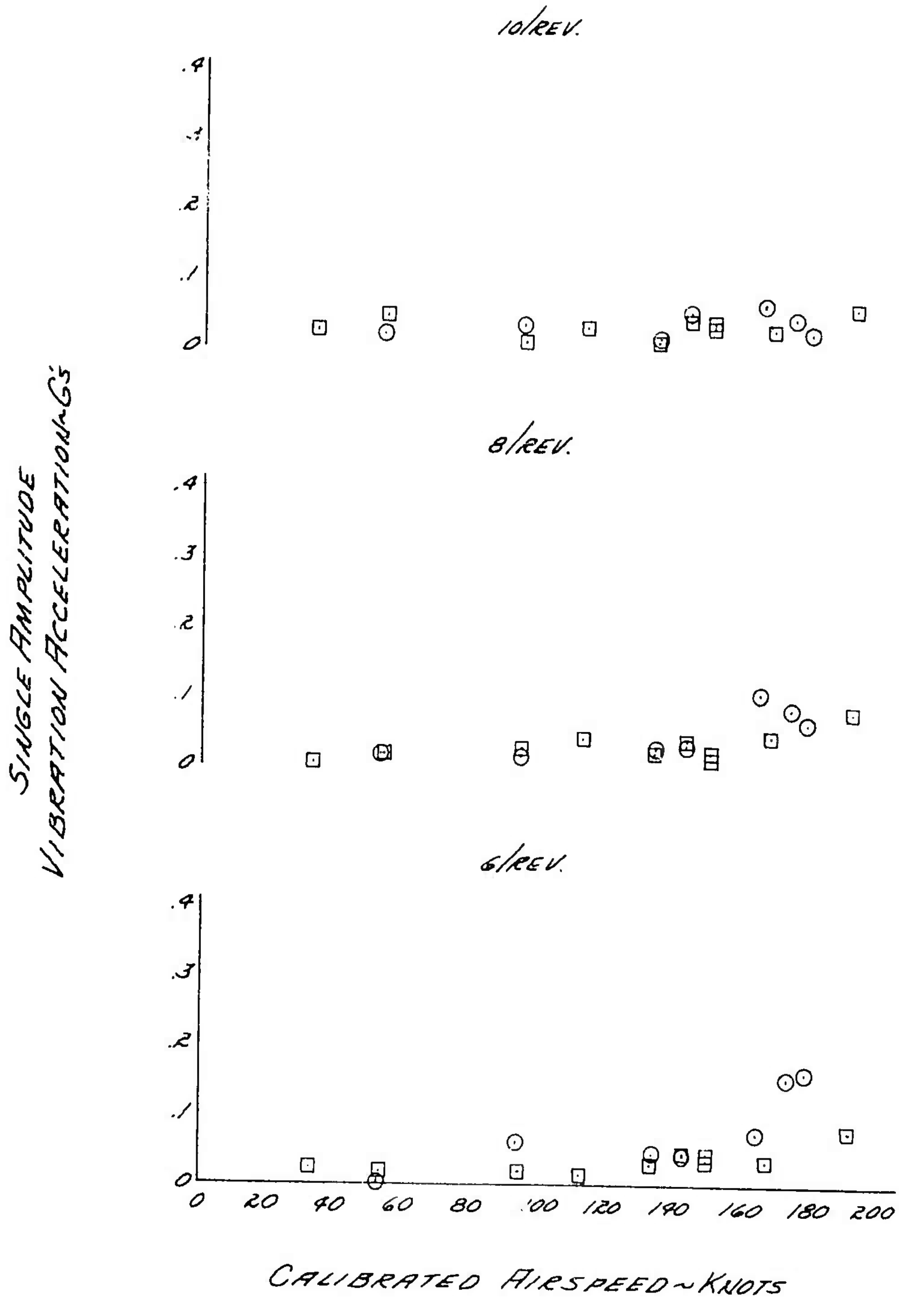


FIGURE NO. 55

VIBRATION CHARACTERISTICS

AH-1G USA S/N 615248

SYMBOL	GROSS WEIGHT ~POUNDS	DENSITY ALTITUDE ~FEET	ROTOR SPEED ~RPM	C.G. STATION ~INCHES	CONFIGURATION
○	7350	3970	324	199.2	HOG
□	8350	2860	324	199.9	GUARANTEE

GUNNER LATERAL

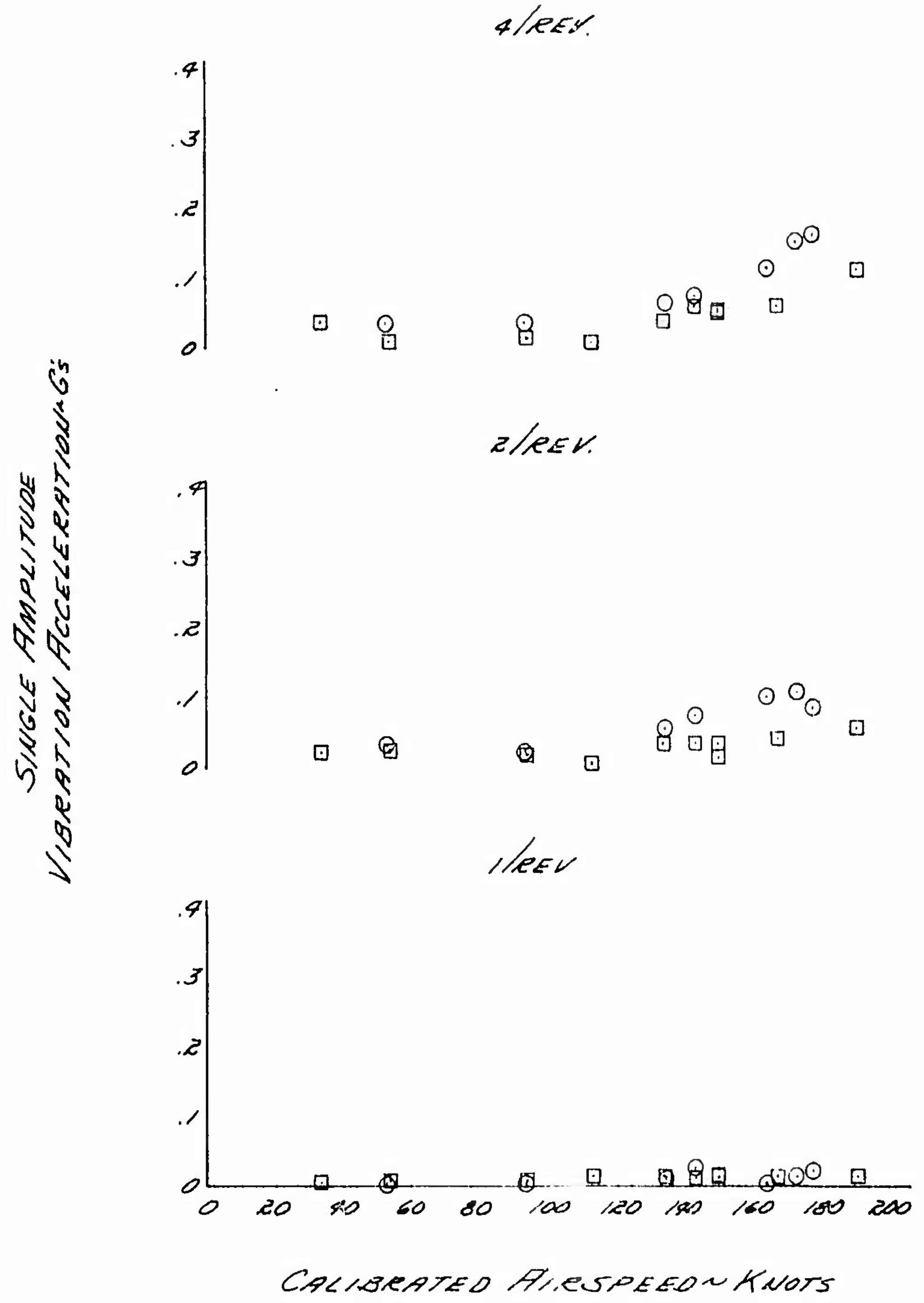


FIGURE NO. 56

VIBRATION CHARACTERISTICS

AH-1G USA S/N 615248

SYMBOL	GROSS WEIGHT ~ POUNDS	DENSITY ALTITUDE ~ FEET	ROTOR SPEED ~ RPM	C.G. STATION ~ INCHES	CONFIGURATION
○	7350	3970	324	199.2	HOG
□	8350	2860	324	199.9	GUARANTEE

GUNNER LATERAL

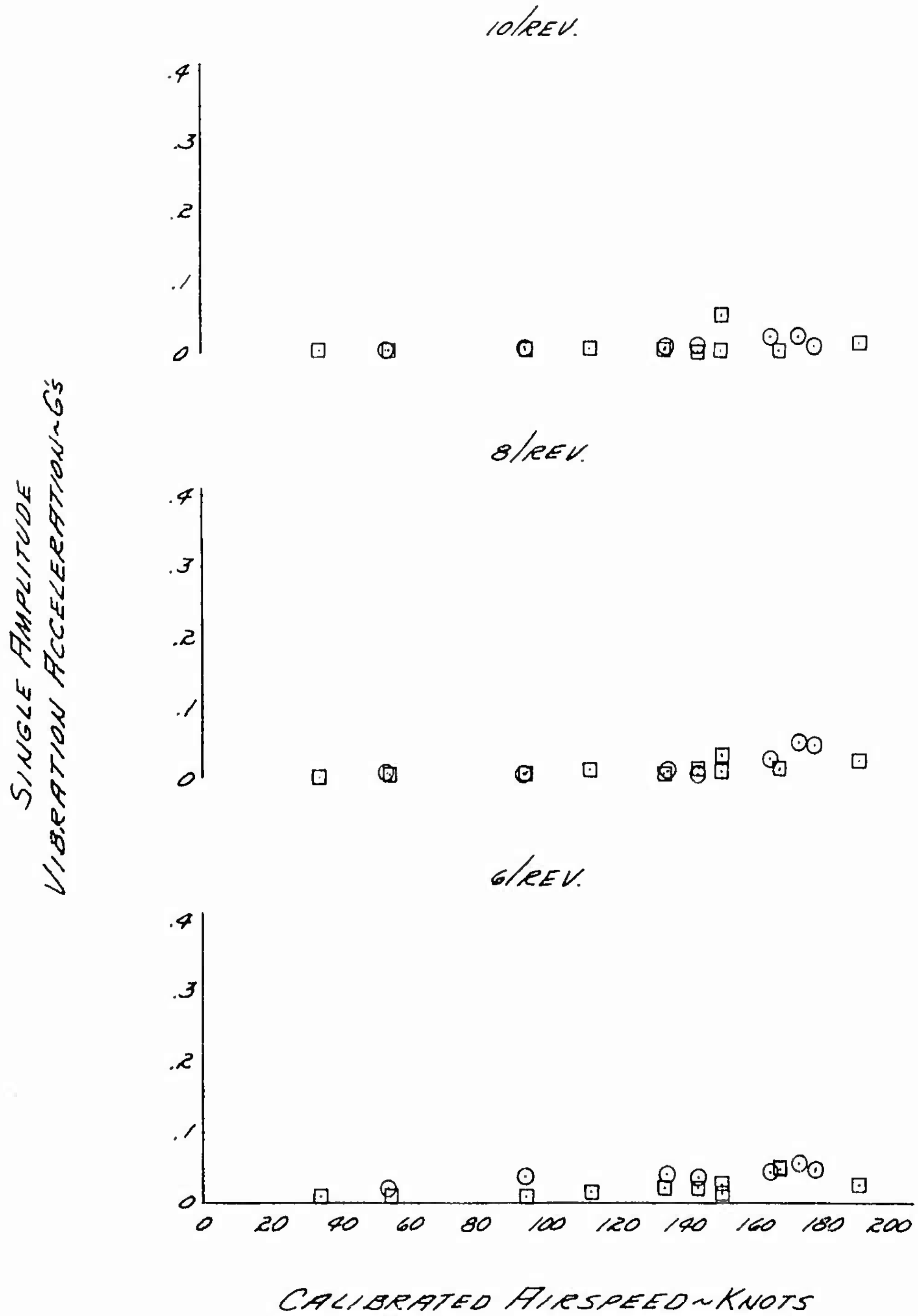


FIGURE NO. 57

VIBRATION CHARACTERISTICS

AH-1G USA S/N 615248

SYMBOL	GROSS WEIGHT ~POUNDS	DENSITY ALTITUDE ~FEET	ROTOR SPEED ~RPM	C.G. STATION ~INCHES	CONFIGURATION
○	7350	3970	324	199.2	HOG
□	8350	2860		195.5	GUARANTEE

PILOT LONGITUDINAL

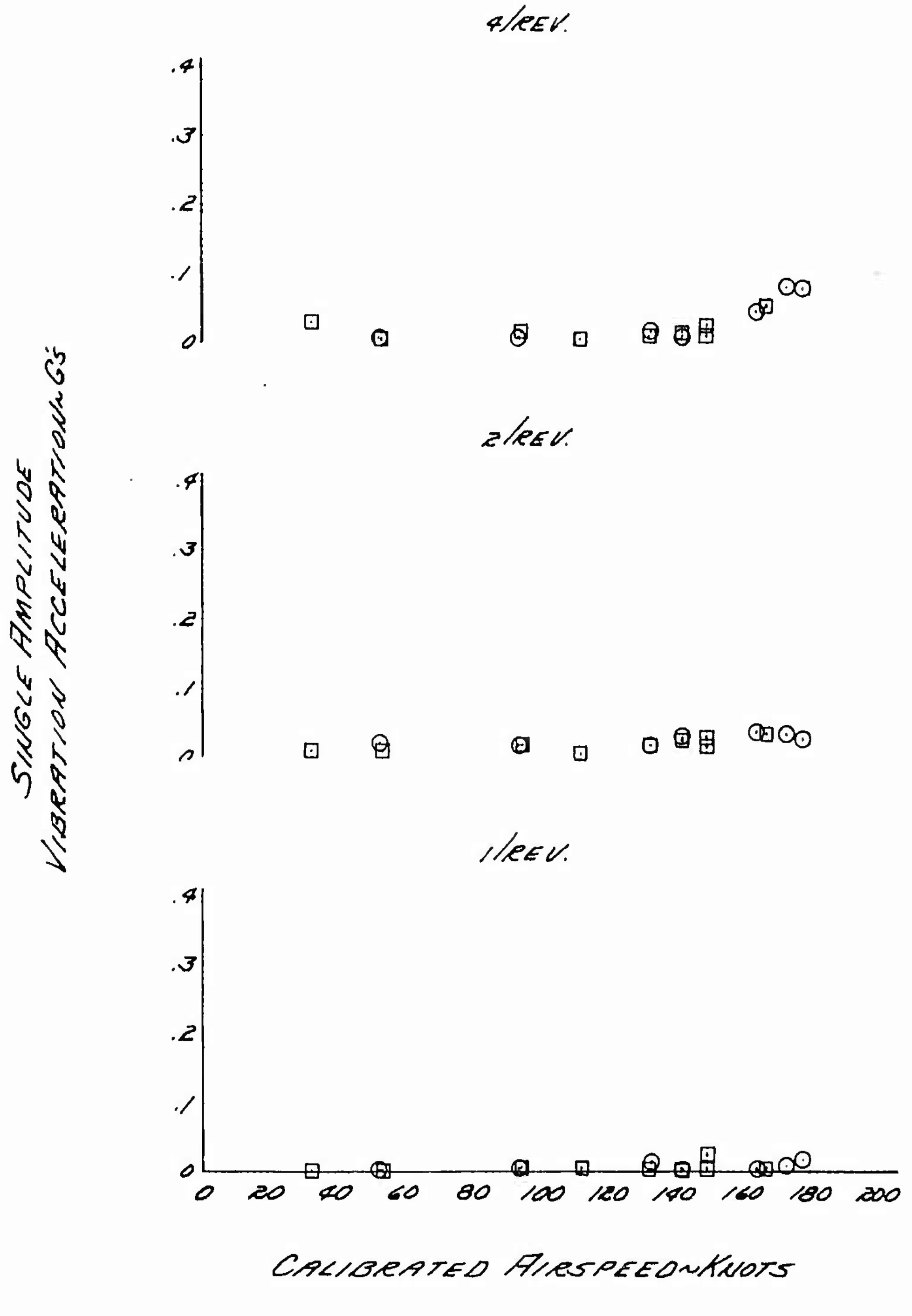


FIGURE NO. 58
VIBRATION CHARACTERISTICS
AH-1G USA S/N 615248

SYMBOL	GROSS WEIGHT ~POUNDS	DENSITY ALTITUDE ~FEET	ROTOR SPEED ~RPM	C.G. STATION ~INCHES	CONFIGURATION
○	7350	3970	324	199.2	HOG
□	8350	2860	324	199.9	GUARANTEE

PILOT LONGITUDINAL

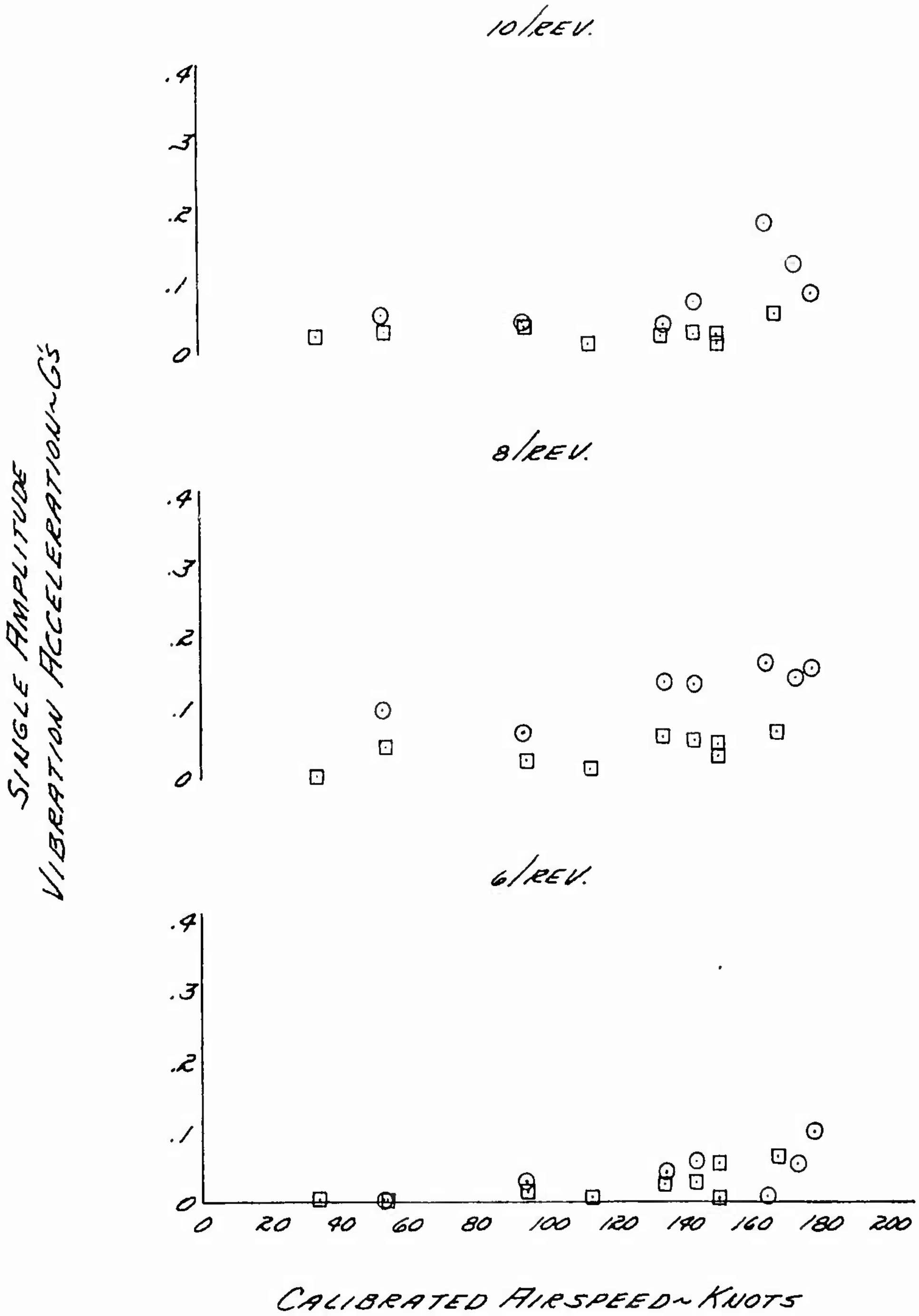


FIGURE No. 59
VIBRATION CHARACTERISTICS
AH-1G USA S/N 615248

SYMBOL	GROSS WEIGHT ~POUNDS	DENSITY ALTITUDE ~FEET	ROTOR SPEED ~RPM	C.G. STATION ~INCHES	CONFIGURATION
○	7350	3970	324	199.2	HOG
□	8350	2860	324	199.9	GUARANTEE

GUNNER LONGITUDINAL

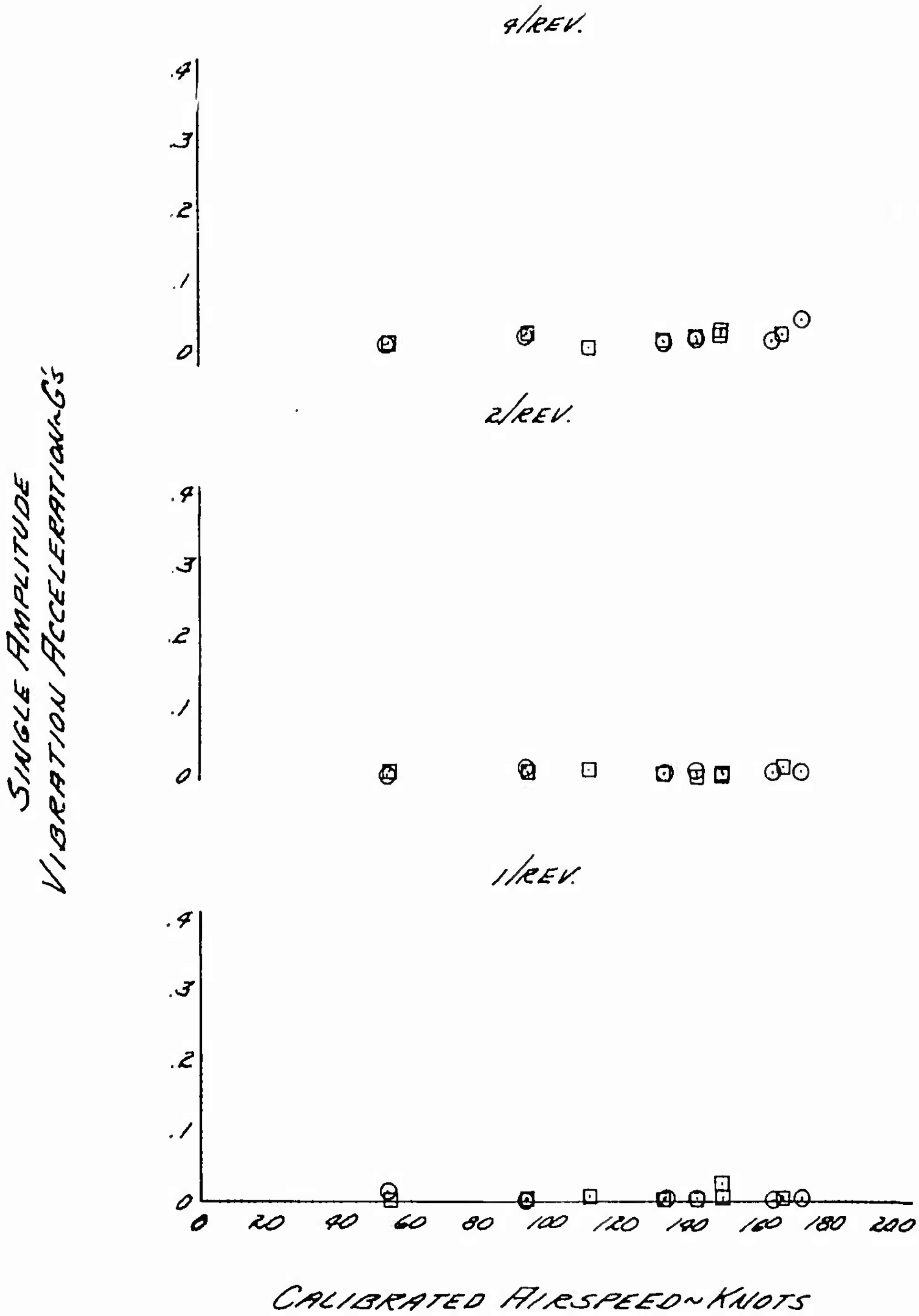


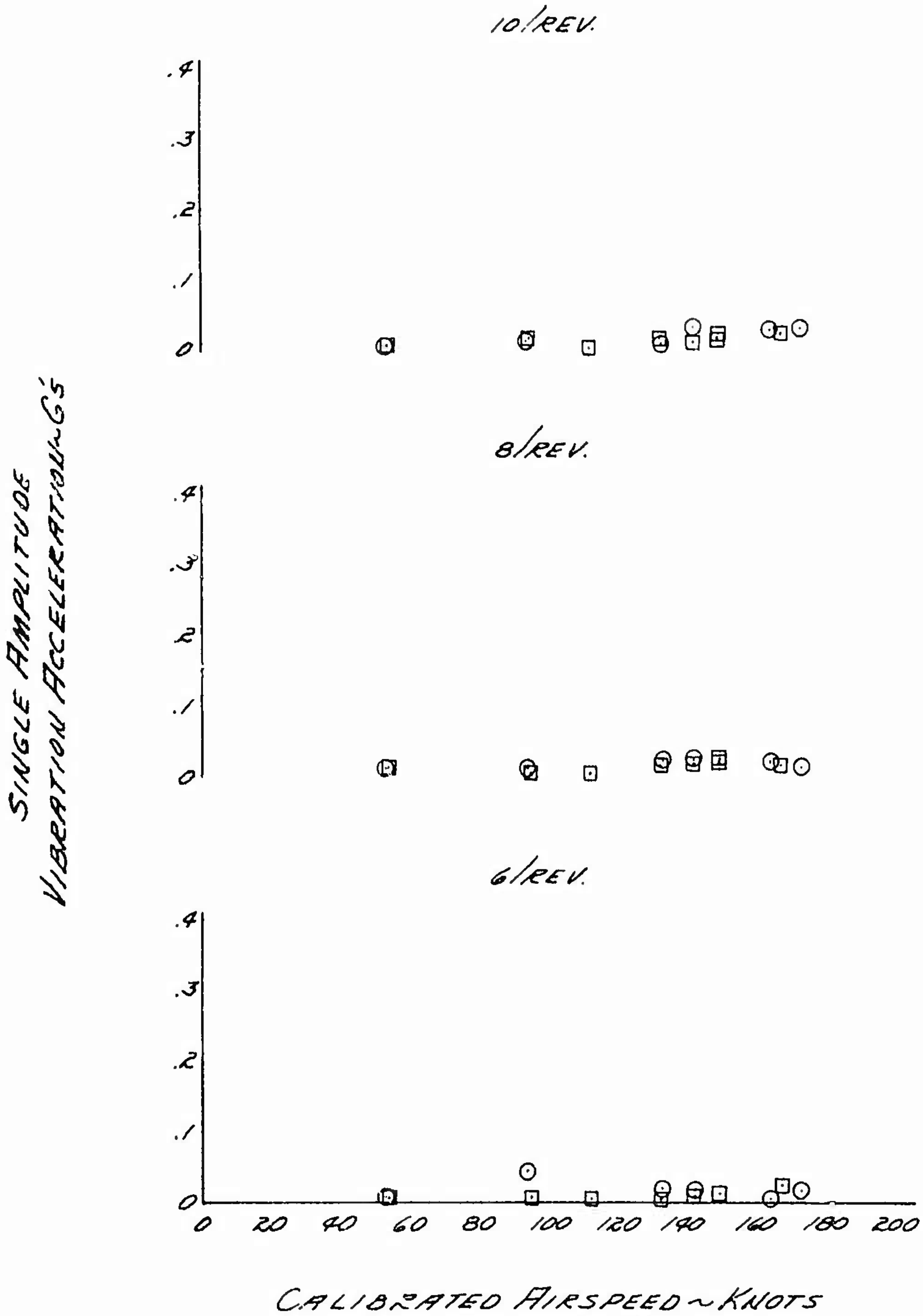
FIGURE No. 60

VIBRATION CHARACTERISTICS

AH-1G USA S/N 615248

SYMBOL	GROSS WEIGHT ~POUNDS	DENSITY ALTITUDE ~FEET	ROTOR SPEED ~RPM	C.G. STATION ~INCHES	CONFIGURATION
○	7350	3970	324	199.2	HOG
□	8350	2860	324	199.9	GUARANTEE

GUNNER LONGITUDINAL



APPENDIX III. TEST INSTRUMENTATION
AH-IG HELICOPTER
SERIAL NO. 66-15248

Flight test instrumentation was installed in the test helicopter by the contractor prior to the start of this evaluation. This instrumentation provided data from the pilot's panel, copilot/gunner's panel, and oscillograph. All instrumentation was calibrated by the contractor and witnessed or approved by the USAASTA flight test engineer. The flight test instrumentation was maintained by the contractor throughout the test program. The following parameters were included in the instrumentation package:

PILOT'S PANEL

Boom airspeed
Boom altitude
Exhaust gas temperature (standard indicator)
Gas producer speed (standard indicator)
Rotor speed
Collective control position
Longitudinal cyclic position
Lateral cyclic position
Directional pedal position
Angle of sideslip
Center of gravity normal acceleration

COPILOT/GUNNER'S (ENGINEER'S) PANEL

Ship's standard system airspeed
Ship's standard system altitude
Rotor speed (standard indicator)
Free air temperature
Fuel totalizer
Oscillograph record counter

OSCILLOGRAPH

Control positions (longitudinal and lateral cyclic, collective, and directional pedals)
Throttle position
SCAS actuator positions (longitudinal, lateral, and directional)

Attitudes (pitch, roll, and yaw)
Angular rate (pitch, roll, and yaw)
Center of gravity normal acceleration
Angle of sideslip
Angle of attack
Linear rotor speed
Engineer's event
Pilot's event
Rotor azimuth
Vibration acceleration (pilot's and gunner's longitudinal, lateral, and vertical)
Longitudinal cyclic control force

APPENDIX IV. AIRCRAFT DIMENSIONS & DESIGN INFORMATION

OVERALL DIMENSIONS

Aircraft length (rotors turning)	52 ft 11.65 in.
Fuselage length	44 ft 5.20 in.
Maximum fuselage width (including stub wings)	10 ft 11.60 in.
Maximum fuselage width (without stub wings)	3 ft 0 in.
Width of skid gear	7 ft 0 in.
Minimum rotor ground clearance (without flexure)	7 ft 10.00 in.

MAIN ROTOR

Rotor diameter	44 ft 0 in.
Chord	2 ft 3.00 in.
Airfoil (Symmetrical Special) 0009 1/3 in.	
Twist	.455 deg/ft
Disc area	1520.4 ft^2
Blade area	49.5 ft^2 per blade
Solidity ratio	0.0651
Preconing angle	2.75 deg
Collective:	
Pitch full travel	11.17 in.
Stick:	
Longitudinal full travel	9.68 in.
Lateral full travel	9.49 in.

TAIL ROTOR

Directive:

Pedal full travel	6.69 in.

AIRCRAFT WEIGHTS

Empty weight	5516 lb
Design gross weight	6600 lb
Test gross weight range	7710 - 8375 lb
Maximum gross weight	9500 lb

APPENDIX V. AH-IG OPERATING LIMITATIONS

1. Limit Airspeed (V_L):

   Hog or Alternate Configuration - 180 KCAS below 3000 feet density altitude. Decrease 8 KCAS per 1000 feet above 3000 feet.

   All Other Configurations - 190 KCAS below 4000 feet density altitude. Decrease 8 KCAS per 1000 feet above 4000 feet.

2. Gross Weight - Center of Gravity Envelope:

   Forward Limit: Below 7000 lbs, Fuselage Station (F.S.) 190. Linear decrease from F.S. 190 at 7000 lbs to F.S. 192.1 at 9500 lbs.

   Aft Limit: Below 7650 lbs, F.S. 201. Linear decrease from F.S. 201 at 7650 lbs to F.S. 200 at 9500 lbs.

3. Sideslip Limits:

   Five degrees at 190 KCAS. Linear increase to 20 degrees at 60 KCAS.

4. RPM Limits (steady state):

   Power on - 6600 to 6400 engine rpm
   324 to 314 rotor rpm
   Power off - 304 to 339 rotor rpm
   transient lower limit 250 rotor rpm
   Power on during dives and maneuvers - 319 to 324 rpm

5. Temperature and Pressure Limits:

Engine oil temperature	95°C
Transmission oil temperature	100°C
Engine oil pressure	25 - 100 psi
Transmission oil pressure	30 - 70 psi
Fuel pressure	5 - 20 psi

6. T53SL-13 Engine Limits - Installed:

Normal rated (maximum continuous) T_5	625°C
Military rated (30-minute limit) T_5	645°C
Starting and acceleration (5-second limit) T_5	675°C
Maximum for starting and acceleration T_5	760°C
Torque pressure	50 psi

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13. ABSTRACT

Part 2 of the AH-1G helicopter Phase B test was conducted at Bell Helicopter Company, Fort Worth, Texas, from 8 September to 26 September 1967 by the US Army Aviation Systems Test Activity, Edwards AFB, California. Part 2 comprised the Phase B testing of the basic configuration (XM-157 rocket launcher outboard on each wing). Earlier tests (Phase B, Part 1) were of the Scout (XM-157 outboard, XM-18 inboard each wing) and Hog (two XM-159 rocket launchers on each wing) configurations. The prototype aircraft for this test was similar to the one previously tested. This test emphasized stability and control testing in the basic configuration. No new deficiencies were detected during this test. The new shortcomings detected during this test were a shallow maneuvering control-free (longitudinal cyclic force) gradient at high airspeeds, nonoptimum static cyclic control force gradients and breakout and friction values, difficult main rotor head inspection, difficult and time consuming gear box inspection, difficult and time consuming oil cooler inlet panel removal, and inadequate seals around cockpit hatches. The deficiencies and shortcomings which existed during Phase B, Part 1, testing still existed during this test.

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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
AH-1G helicopter Prototype Shortcomings Deficiencies Helicopter stability and control Engineering flight test						

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